Electronic Engineering

Incorporating . . . ELECTRONICS, TELEVISION & SHORT WAVE WORLD

VOL. 20 No. 245 JULY 1948 PRICE 2/-

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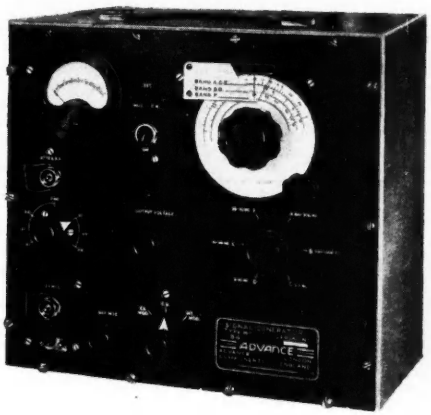
ADVANCE SUB-STANDARD SIGNAL GENERATOR

Covering all Television Ranges



Model A : 100 Kc/s—70 Mc/s in six bands.
Model B : 30 Kc/s—30 Mc/s in six bands.

Negligible Stray radiation.

Output accuracy ± 1 db.
Monitored by crystal voltmeter.

Directly calibrated

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Advance Signal GENERATOR TYPE B4

CALIBRATION ACCURACY : ± 1% Directly Calibrated

R.F. OUTPUT : Monitored by crystal voltmeter continuously variable from 1 μV to 100 mV. Accuracy ± 1Db.

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STRAY FIELD : Negligible.

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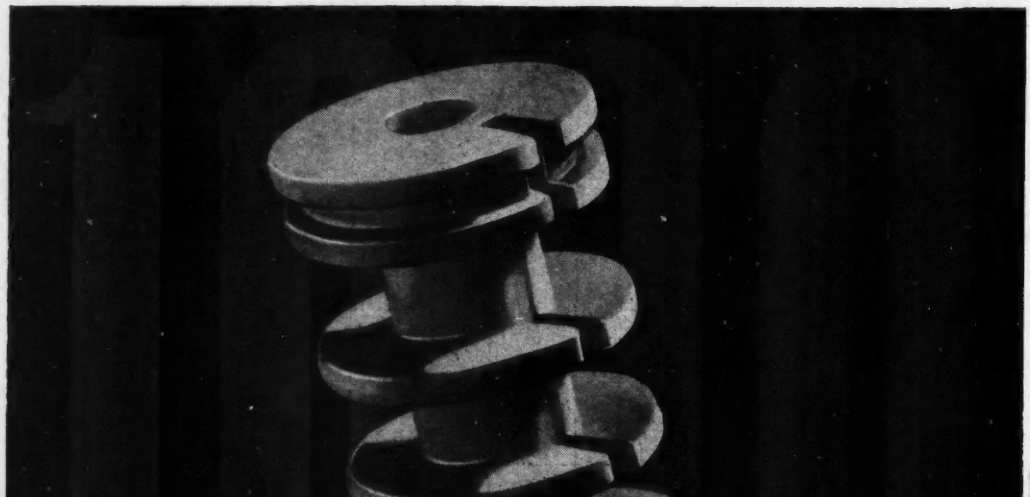
ADVANCE COMPONENTS LTD., BACK RD., SHERNALL ST., WALTHAMSTOW, LONDON, E.17. *Phone : Larkswood 4366-7-8*



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Fifteen years ago we introduced the first British-made low-loss ceramic. **To-day the range of Frequentite** components covers more than a thousand pieces of every shape and size. With such a store of manufacturing experience we are able to offer advice backed by practical knowledge on your insulation problem. Please consult us before you finalize your design.

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S.P.24

CLASSIFIED ANNOUNCEMENTS

The charge for these advertisements is twelve words or less 5/- and 4d. for every additional word. Box number 2/- extra, except in the case of advertisements in "Situations Wanted" when it is added free of charge. A remittance must accompany the advertisement. Replies to box numbers should be addressed to: Morgan Bros. (Publishers) Ltd., 28, Essex Street, Strand, London, W.C.2 and marked "Electronic Engineering." Advertisements must be received before the 10th of the month for insertion in the following issue.

OFFICIAL APPOINTMENTS

Vacancies advertised are restricted to persons or employments excepted from the provisions of the Control of Engagement Order, 1947.

APPLICATIONS are invited for temporary appointments in Ministry of Supply Research Establishments, chiefly at Farnborough (Hants); Leicester; Malvern; Sevenoaks (Kent); Woolwich; Waltham Abbey and Shoeburyness (Essex). Vacancies are in Scientific Officer and Experimental Officer Grades in the fields of Radar and Electronics, particularly centimetre wave techniques, and applications to general research needs and computing devices, aircraft and weapon testing, aircraft navigation and landing, automatic control systems, small servo and other mechanisms, fire control.

Candidates for Scientific Officer grades should have an Honours degree in Physics or Mathematics or equivalent with appropriate experience. For Experimental Officer grades a Higher School Certificate or equivalent with laboratory or workshops experience is the minimum qualification.

Applicants must be of British Nationality. Salaries, varying according to the different grades, age, qualifications and experience, are within the following provincial ranges:—£200–£1,155 (men) and £200–£997 (women).

Application forms and salary details are obtainable on request (by postcard, quoting reference number A.161/48) from Technical and Scientific Register (K), York House, Kingsway, London, W.C.2.

THE QUEEN ELIZABETH HOSPITAL BIRMINGHAM. The Hospital requires immediately the services of a skilled and experienced Laboratory Technician to take charge of the Physics workshop, which designs and prepares apparatus for the Radiotherapy Department and other general physics apparatus for other Hospital purposes.

The workshop equipment consists of lathes and milling machines, including micro-precision lathe and drilling machine. The technician must be a skilled operator of this equipment. Experience in a University or a Hospital Physics workshop is desirable but not essential. The commencing salary is within the range of £375 to £450 per annum, according to experience.

Applications, which should be sent in at once to the undersigned, should be accompanied by two recent testimonials and the names of two independent referees. G. Hurford, House Governor, Queen Elizabeth Hospital, Birmingham, 15.

SITUATIONS VACANT

MURPHY RADIO LTD. have vacancies in the Electrical Design Department for: (1) Senior Radio Engineer with Hons. degrees or equivalent in Physics or Electrical Engineering and several years' industrial experience of radio receiver or television design work. (2) Radio Engineers with good academic qualifications in Physics or Electrical Engineering, preferably with some industrial experience. Applications, giving particulars of training and experience, should be forwarded to the Personnel Manager, Murphy Radio Ltd., Welwyn Garden City, Herts.

ELECTRONIC CIRCUIT ENGINEERS required for research and development work; good academic qualifications and apprenticeship, industrial or research experience essential. Knowledge of any of the following subjects desirable: radar and television pulse techniques, centrimetric components, time-base generators, A.C. and D.C. amplifiers, feed-back amplifiers, servos, especially low power electro-mechanical stabilised power supply units, data transmission systems, cable form layouts. Some mathematical ability is desirable. Write, with full details of qualifications, experience, age and salary required, to Personnel Manager, Sperry Gyroscope Company Ltd., Great West Road, Brentford, Middlesex.

ELECTRONICS ENGINEER, H.N.C. or Degree standard, age 30/40, five years experience required by Research Section of large engineering firm in the Midlands for the construction of the vibration indicating and recording gear, strain gauge recording apparatus and the maintenance of laboratory equipment. 5-day week. Reply stating age, experience and salary required to Box No. 440, 8 Serle Street, London, W.C.2.

THE ENGLISH ELECTRIC VALVE COMPANY invites applications for a Valve Engineer for the research laboratory. This is a senior appointment calling for an essentially practical man with wide experience in the design and manufacture of electronic tubes. A Science Degree together with a knowledge of photo-electric processes would be advantageous. The applicant should be a good organiser and capable of controlling staff. Remuneration will be according to age, qualifications and experience. Apply giving full details of age, qualifications and salary required to, Chief of Research, English Electric Valve Co., Ltd., Waterhouse Lane, Chelmsford.

TECHNICAL REPRESENTATIVE required by large radio component manufacturer in the east London area. Suitable applicant must have technical knowledge and practical experience in the industry and should have thorough knowledge of the radio industry. State age, qualifications, experience and salary to Box 284, E.E.

AUDIO FREQUENCY DEVELOPMENT ENGINEER required. Applicant must have sound fundamental theoretical knowledge and practical experience. Salary according to qualifications. Apply in first instance to Box 283, E.E.

INSTRUMENT MAKERS with moving coil experience, N.W. London. Box 285, E.E.

RADIO ENGINEER, preferably aged 25–30, with an Honours degree or equivalent qualifications and with experience in circuitry and advanced development work, is required for research in the field of telecommunications. Apply by letter only to the Director, Research Laboratories of the General Electrical Co., Ltd., North Wembley, Middlesex, stating age, academic record and experience.

PHYSICIST WITH UNIVERSITY DEGREE required to undertake research in connexion with development of radio frequency equipment for medical purposes. Salary dependent on qualifications and experience. Box 286, E.E.

JIG AND TOOL DESIGNER required in connexion with interesting range of production embodying X-ray and electronic apparatus. Good opportunity for man requiring prospects of long term steady employ, to ally himself with a well-established organisation in mid Herts. Apply, giving full particulars, to Box 287, E.E.

DRAUGHTSMAN (Senior) in connexion with light current electronic measuring equipment. Excellent opportunity for man placing score on good steady employ, with long term prospects for a competent man. Apply, giving full particulars to Box 288, E.E.

X-RAY ELECTRONICS. The following are required in St. Albans area for development and pilot production of X-ray equipment: (1) Senior Tester with knowledge of general electrical and electronic control systems and preferably some experience of X-ray equipment. (2) Assistant Tester with general electrical and electronic testing. Apply giving full particulars, to Box 289, E.E.

CONSULTING X-RAY PHYSICIST. Services of X-ray Physicist required in St. Albans area on a part-time consultative basis to aid in development and pilot production of new X-ray equipment. Apply, giving full particulars, to Box 290, E.E.

A LARGE VALVE MANUFACTURING CONCERN in S.W. London require Junior Assistants in their Cathode Ray Tube and Transmitting Valve Departments. Candidates must be graduates in Physics or Electrical Engineering, but no previous experience necessary. Salary £350 plus, according to age and qualifications. Reply to Box E.E. 585, L.P.E., 110, St. Martin's Lane, W.C.2, and quote reference C/369.

VACANCIES EXIST for Junior Engineers or Physicists for development and research work in connexion with electrical measurements and test methods. Candidates should have qualifications up to Higher National or Degree Standard and must have aptitude for electronics. Applications are invited by the Personnel Manager, Standard Telecommunication Laboratories Ltd., Progress Way, Enfield, Middlesex.

A VACANCY EXISTS for a Glass Blower or improver in new Research Laboratory. Should have experience on lathe work and glass-metal seals. Applications stating experience are invited by the Personnel Manager, Standard Telecommunication Laboratories Ltd., Progress Way, Enfield Middlesex.

A LIGHT ELECTRICAL ENGINEERING FIRM in the Midlands has several vacancies on their research staff as follows:—(a) Senior Research Engineer to take charge of a new and interesting valve research project. He should have some knowledge of electron optics as applied to cathode ray tubes and similar articles, photo-electric emission, with knowledge of industrial valve techniques. (b) Research Engineer for valve work in the above section. (c) Research Engineer to work on electro-magnetic systems with a detailed knowledge of magnetic properties of materials. (d) Research Engineer to work on light A.C. circuitry and circuit analysis (not electronic). (e) Research Engineer having a strong mathematical bias for advanced objective research into certain physical properties of metals and semi-conductors. Good technical ability is expected for all these posts, together with some ten years research experience for (a) and at least two, and preferably four or five years for the remainder. Salary in accordance with qualifications and experience and ability to lead in experimental work. Box M.3516, Haddons, Salisbury Square, Fleet Street, E.C.4.

BELLING AND LEE LTD., Cambridge Arterial Road, Enfield, require a radio engineer with a flair for component design and development. Previous experience not essential but applicants should possess wide knowledge of component uses in radio and electronics and possess sound background in radio physics. Applications (by letter only) stating age, experience and salary required will be treated in strict confidence.

ELECTRONIC ENGINEER required in N.W. London district to undertake development of electronic equipment. Applicants should possess a degree and have had experience in this class of work. Knowledge of optics will be an advantage. Applications should state age, full particulars of experience and salary required. Write Box 487, c/o 7, Coptic Street, W.C.1.

MANAGER with energy required for Scientific Instrument Department of progressive exporters. Combination technical, including electronics, and commercial knowledge essential. Good prospects for right man. Reply Box 295, E.E.

RADAR ENGINEERING COMPANY in London area require immediately Chief Mechanical Designer. Applicant must have sound basic knowledge of mechanical engineering and considerable experience in the application of mechanical design in the electronic field. Particular regard will be paid to ability in small mechanical design and experience of marine radar will be an asset. The successful applicant will be required to take charge of new department specialising in the design of ships radar equipment and the post offers good possibilities of future progress. Commencing salary will be between £750–850 per annum, dependent on experience. Write in first instance fullest details of past experience and qualifications. Box 294, E.E.

SENIOR GLASSBLOWER required for laboratory engaged on development of special types of cathode ray tubes and other electronic devices. Thorough knowledge of lathe and bench work, glass-metal seals, etc., with all types of glass essential. Housing accommodation can be arranged in near future. Apply with details of experience, salary required, etc., to Pye Ltd., Meadowcroft Laboratories, Church Street, Cambridge.

DEVELOPMENT ENGINEER 26/35 years with technical qualifications for position in works laboratory. Experience of manual and servo operated remote control apparatus and in the design and testing of small A.C. motors essential. Some knowledge of electrical measurements and electronics. Must be able to carry out experimental work with minimum instruction and supervision. Write giving full details of training, experience and salary required to Muirhead and Co., Ltd., Elmers End, Beckenham, Kent.

COMPETENT SENIOR SERVICE ENGINEER required for miniature valve amplifiers and similar equipment. Must be able to diagnose faults and take charge of small Service Department. London area, 5-day week. Reply by writing, giving full address, Box 296, E.E.

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CLASSIFIED ANNOUNCEMENTS (Cont'd.)

ASSISTANT DEVELOPMENT ENGINEER 21/25 years, H.N.C. standard for works laboratory. Experience of remote control apparatus, manual and servo operated, and in the design and testing of small A.C. motors is desirable. Some knowledge of electrical measurements and electronics is necessary. Write stating age, training, experience and salary required to Muirhead and Co., Ltd., Elmers End, Beckenham, Kent.

REQUIRED BY FIRM IN S. WALES area, Electrical Engineer, capable of initiating design of electrical and electronic test gear, to take charge of inspection of domestic and other electrical products. Reply, giving details of previous appointments in chronological order to Box 299, E.E.

WELL-KNOWN FIRM OF PRECISION ENGINEERS and Scientific Instruments Makers requires Research Physicists and Engineers for the Electronics Division at their recently established Research Laboratories situated on the Northern outskirts of London. Vacancies exist for: (1) A Senior Research Engineer, age 30–40 to take charge of an Electronics Division. Salary £1,000/£1,500 per annum, according to qualifications and experience. (2) Research Engineers to take charge of small research groups. Age 25/35. Salary £700–£1,000 according to age and experience. (3) Junior Research Engineers. Age 21–28. Salary £325–£700 according to age and experience. Candidates for posts (1) and (2) are expected to have an Honours degree in Physics or Engineering, and to have had experience of research in advanced circuit techniques. Candidates for posts under (3) are expected to have an Honours degree or experience in electronic research. All posts will be permanent and a superannuation scheme, to which the firm contributes, will be available to those successful candidates who wish to join. Applications must be made in writing by the 15th July, 1948. Before acceptance, candidates will be expected to attend an interview in the vicinity of London. Apply Box 291, E.E.

DISTRICT MANAGER FOR SCOTLAND with Glasgow Headquarters required by major Cinema Projection and Sound Equipment Company. Duties include responsibility for sales, service and engineering activities. Applications solicited from Engineers with good sales and administrative experience in Electronic Industry. Successful applicant will be provided a period of specialised training at London Headquarters and in Provincial area. Applicants should provide detailed information covering the following: age, education, qualifications, engineering, sales and administrative experience, whether car owner, commencing salary required. Box 298, E.E.

THE UNIVERSITY OF LIVERPOOL. Glassblower required in the Department of Physics. Experience in hard and soft glasses and glass-metal seals essential. Salary in accordance with age and experience. Applications, which should include particulars as to age, qualifications and experience, together with copies of testimonials, should be received not later than August 21st, 1948, by the undersigned. Stanley Dumbell, Registrar.

ELECTRIC AND MUSICAL INDUSTRIES LTD., have vacancies for the following drawing office personnel, on electronic, telecommunication and electromechanical engineering: (a) Senior Electro-mechanical Designer-Draughtsmen. (b) Senior Mechanical Designer-Draughtsmen. (c) Senior Electrical Designer-Draughtsmen. (d) Detail Draughtsmen. Apply, stating age, fullest details of experience and salary required to Personnel Department, E.M.I. Ltd., Blyth Road, Hayes, Middlesex.

SENIOR MECHANICAL DRAUGHTSMAN. The South Western Division of a leading company in the electronic equipment field require a Draughtsman, age 25/40, for work in their Development Drawing Office. Applicants should have had experience in laying out and detailing electronic equipment, be capable of preparing quickly and accurately sketch drawings at development stage and of making (with minimum of supervision) full manufacturing drawings for production runs. Salary according to qualifications and experience. Full details to Box 301, E.E.

There is a World Shortage of competent electronic engineers. **RADIO CORPORATION OF AMERICA** would welcome enquiries from qualified engineers who are about to reside in the United States. Experienced electronic engineers are needed for design and development work in radio, radar, television and allied electronic fields. Positions for both electrical and mechanical engineers are avilable in Philadelphia area and elsewhere. Write stating age, details of education and experience to Chief Engineer, Radio Corporation of America, RCA Victor Division, Camden, N.J., U.S.A.

ELECTRONIC ENGINEERING. There are still several vacancies for interesting and progressive work in the design laboratories of E.M.I. Engineering Development Ltd., at Hayes, Middlesex. Vacancies are primarily for men with Honours Degrees and some practical design experience: age 25 to 30. Starting salaries £400 to £550. There are particular vacancies for men interested in audio-frequency engineering, television and communication receivers, electron optics, and tropicalised radio components. Send full details of experience and qualifications to Personnel Department, E.M.I. Engineering Development Ltd., Hayes, Middlesex.

PHYSICIST REQUIRED for a new research laboratory in Essex dealing with plastics, powder metallurgy, recording and electronics. Possibility of a small flat being available in Essex near the laboratory. Age 25–30. Applicants should give full details of experience and salary required etc. to Box 302, E.E.

CHEMIST REQUIRED for a research laboratory in Essex dealing in plastics and powder metallurgy. Possibility of a flat in the country being available. Age 25–35. Applicants should give full details of experience and salary required etc. to Box 303, E.E.

VACANCIES for all grades of electronic and mechanical engineers. Must have good technical training and be willing to specialise in one field. Salaries up to £1,000 per annum according to ability. Box 304, E.E.

TECHNICAL DESIGNER required by radio and television manufacturer. Higher National Certificate or Graduate in Physics or Electrical Engineering; able to organise own research and design department. State age, qualifications, experience and salary required. Box 305, E.E.

SITUATIONS WANTED

SIGNALS OFFICER, 24, Stud. I.E.E., C. & G., etc., 5 years radio research, 2 years radar development, available August. Requires position offering scope for initiative, drive and ambition. Box 293, E.E.

MATHEMATICAL PHYSICIST, Honours graduate, both Mathematics and Physics Specials, A.Inst. P., seeks change of post. Original publications, research experience in microwaves. Would consider different field. Box 292, E.E.

A YOUNG MAN, age 20, seeks vacancy as Junior Radio Engineer. Holds Intermediate Certificate Radio Communication, C. & G. Excellent recommendation from School Principal. Please reply Box 300, E.E.

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ELECTRICAL ENGINEERING DEPARTMENT
Head of Dept.: W. H. Date, B.Sc. (Eng.), M.I.E.E.

Full-time Day Courses are provided in Electrical and Telecommunication Engineering. The courses, which extend over a period of three to four years, prepare for the Higher National Diploma and professional examinations and for the B.Sc. (Eng.), Lond. **Session 1948-9 begins on September 14, 1948. Evening Courses,** in these subjects and in Radio Service Work commence on Monday, 20th September. The courses prepare for the Ordinary and Higher National Certificates and for the City & Guilds of London Institute examinations. New students will be enrolled on 15th and 16th September, 6-8 p.m. Prospectuses may be obtained on application to the undersigned. J. C. Jones, Director of Education.

COMPLETE CORRESPONDENCE COURSE, covering Amateur and C. and G.I. Examinations, consisting of 12 lessons. Students trained for Certificates of the City and Guilds of London Institute. Send for particulars. Orthic-Modern Institute, 72, St. Stephen's House, Westminster, S.W.1.

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MISCELLANEOUS

WE WILL BUY at your price used radios, amplifiers, converters, test meters, motors, pick-ups, speakers, etc., radio and electrical accessories. Write, phone or call, University Radio Ltd., 22, Lisle Street, London, W.C.2. GERard 4447.

PHOTOGRAPHY. We specialise in advertising and catalogue-photography, and in series photographs for instruction sheets. Our pictures tell the story. Behr Photography, 44, Temple Fortune Lane, N.W.11 (SPEdwell 4298).

CHARTER for Technical Staffs in the Engineering and Metallurgical Industries. The proposals in the Charter have aroused great interest in the profession. They are being widely discussed. Any Engineer or Metallurgist may have a copy free on request. Write to the Publishers, The Association of Scientific Workers, 15, Half Moon Street, London, W.1.

COILWINDING. Layer, wave and progressive wave winding to specification. Prototypes or quantity production of units and assemblies. Design and development. Rynford Industries Ltd., 17, Arwenack Street, Falmouth, Cornwall.

PATENTS

THE PROPRIETORS of British Patent No. 568,58[illegible] relating to "Improvement in Optical Comparatory" desire to grant licenses under the patent on reasonable terms for the purpose of ensuring the full commercial development and practical working of the invention. Enquiries should be addressed to Box 297, E.E.

THE PROPRIETORS of British Patent No. 564,19[illegible] relating to Electronic translating devices, are desirous of entering into arrangements by way of licence or otherwise on reasonable terms for the purpose of exploiting the same and ensuring its full development and practical working in this country. Interested parties who desire a copy of the Patent Specification and further particulars should apply to S. E. Matthews, of 14–18, Holborn, London, E.C.1.

THE PROPRIETORS of British Patent No. 561,43[illegible] relating to Electric relay systems for automatic control of variable conditions, are desirous of entering into arrangements by way of licence or otherwise on reasonable terms for the purpose of exploiting the same and ensuring its full development and practical working in this country. Interested parties who desire a copy of the Patent Specification and further particulars should apply to S. E. Matthews, of 14–18, Holborn, London, E.C.1.

THE PROPRIETORS of British Patent No. 564,19[illegible] relating to Electronic translating devices, are desirous of entering into arrangements by way of licence or otherwise on reasonable terms for the purpose of exploiting the same and ensuring its full development and practical working in this country. Interested parties who desire a copy of the Patent Specification and further particulars should apply to S. E. Matthews, of 14–18, Holborn London, E.C.1.

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CLASSIFIED ANNOUNCEMENTS
continued on Page 4

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RADIO SERVICING TECHNIQUE
ELEMENTARY TRANSMISSION AND LINES
ENGINEERING PRACTICE

The Course will be of two years' duration and will prepare students for the Final Certificate of the City and Guilds of London Institute in Telecommunications Engineering. Application Forms for admission and further particulars obtainable from the Principal. (1412)

CLASSIFIED ANNOUNCEMENTS (Cont'd.)

0 to 350 mA Moving Coil R.F. Meters, 3s. 9d.; generators, ball bearing for 12, 24 and 200 volts D.C. 4s. 6d.; Neon tubes, 1s; American I.F. chokes, 3s. 6d.; American transformers, 2s.; valves from 1s. 6d.; 230/115 transformers, 21s. Thousands of electronic parts in stock. Stamp for list. Jack Porter Ltd., "Radio," 22/31, College Street, Worcester.

IN STOCK. Rectifiers, Accumulator Chargers, Rotary Converters, P.A. Amplifiers, Mikes, Mains Transformers, Speakers of most types, Test Meters, etc. Special Transformers quoted for.—University Radio, Ltd., 22, Lisle Street, London, W.C.2. GERrard 4447.

POTENTIOMETERS 2-GANG, 1 Meg.-1 Meg., medium spindle, 3s. 3d; 30K-30K., ¼ in. spindle, 3s. 9d; Wirewound, 300 ohms, 6 Watts, c/w knob, 3s. 6d.; 1200 ohms, 20 Watts, ceramic, 3s. 6d.; 25K., 3 Watts, 3s. 6d. a pair; Carbon, 20K., 100K., medium, spindles, 1s. 9d. each; 250K., screwdriver control, 7s. per doz. All post free. Hopton Radio, 1, Hopton Parade, Streatham High Road, S.W.16.

12 VALVE WESTERN ELECTRIC R1585, midget receiver 234–258 Mc./s. Size 11 in. by 6 in. by 5 in. valves 3 by 6AK5. 7 by 9001. EBC33 and 12A6. 4 gang RF. tuner. F.C. I.Fs. B.F.O. Det. AVC and output. Easily converted to 6 or 12 v. Car Radio. No extra coils or other components required except power unit and speaker. All smoothing in the receiver. A remote control box is included with the set, but no connecting cables are available. These Ex-Govt. receivers are in cartons and in brand new condition. Price £4 10s. each, carriage and packing 7s. 6d. extra. 12 v. 200 v. Mallory Vibrapacks for above sets 15s. each. complete. Goodmans 3½ in. speakers, £1 each, H. English, The Maltings, Rayleigh Road, Hutton, Brentwood, Essex.

GENUINE ARMOUR MAGNETIC Recording Wire, sufficient for 1 hour, mounted on standard spools in maker's sealed tins. £3 each. Harris, Strouds, Pangbourne, Berks.

MARCONI STANDARD SIGNAL GENERATOR type TF144G, 85 Kc./s to 25 Mc./s, perfect condition complete with mains lead and output lead. £75 for quick sale. Collier, 86 Copse Lane, Headington, Oxford.

BACK NUMBERS. January 1939 to May 1948. Complete less 8. 105 copies. Binders, etc. Offers to Gwynn, 17 Oakroyd Close, Potters Bar, Middlesex.

ENAMELLED, STANDARD, SYNTHETIC and covered copper wires in all gauges, ex stock. State gauges and quantities required to Box 282, E.E.

TELEVISION AERIALS. Baldwin Instrument Co., Ltd., have for disposal a limited number of sets of duralumin tubes cut to correct length suitable for television aerials. Price, carriage paid, dipole only 15s., dipole and reflector 25s. Cash with order or C.O.D. Baldwin Instrument Co., Ltd., Brooklands Works, Dartford, Kent.

THE ENOCK PICK-UP is now available in limited quantities. Moving coil (licenced under Patent No. 538,058) with precision made polished diamond stylus. Weight at needle point, ⅛ oz. No resonances within the recorded range. Price, £36 15s. inc. tax. Full particulars from Joseph Enock Ltd., 273a High St., Brentford, Middlesex. EALing 8103.

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TELEVISION CONSTRUCTORS! We can supply: Focus and scanning coils for high and low impedance, for 9 in. 12 in. and 15 in. tubes. Rubber masks. Mazda CRM91, G.E.C. 6501, Mazda CRM121 tubes. S.T.C. rectifiers, H.V. capacitors, copper wires. All ranges of resistors and capacitors, etc. "Electronic Engineering" Home Built Televisor 2s. 9d. inc. postage. E. A. Porritt, 13/27, Wastdale Road, Forest Hill, S.E. 23. FORest Hill 1292.

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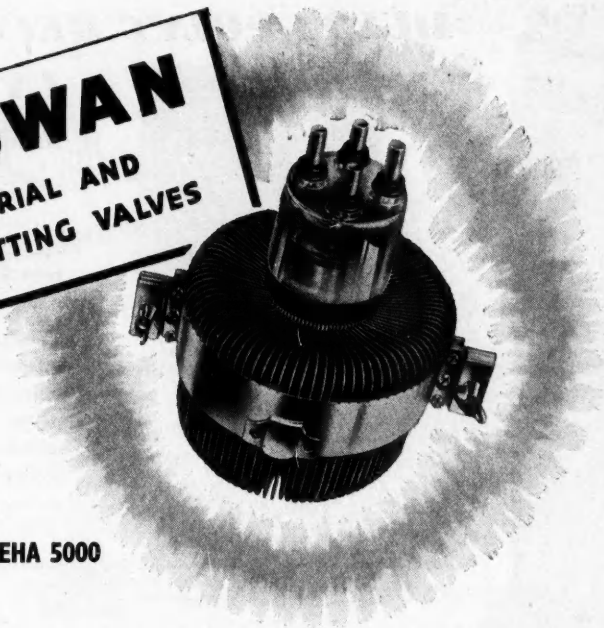
INDUSTRIAL AND TRANSMITTING VALVES



EHA 5000

EQUIVALENTS

EDISWAN	U.S.A.
EHW 5000	889
ESA 892	892R
ESW 892	892
ESW 207	207
ES 204A	204 A
ESU 400	575A
ESU 866	866/866A
	18049 G.E.
	2000 RCA
68506	12x825
68510	

The EHA 5000 is a forced air cooled triode valve for use as an R.F. Amplifier or Oscillator.

The design minimises lead inductance and makes the valve particularly suitable for H.F. applications. This valve is the direct equivalent of the American type 889R.

RATING

Filament Voltage	11 volts.
Filament Current	125 amperes
Maximum Anode Voltage	18.5 KV.
Maximum Anode Dissipation	5 KW.
Amplification Factor	20
Mutual Conductance	*10 MA/V.
Impedance	2,000 ohms
Maximum Operating Frequency	†25 Mc/s.
Power Output	8 KW.

* *Taken at Va = 5 KV. Ia = 1 amp.*

† *May be operated at higher frequencies provided the maximum values of anode voltage and power input are reduced.*

INTER-ELECTRODE CAPACITANCES

Anode-Grid	20.7μμF.
Anode-Filament	2.5μμF.
Grid-Filament	19.5μμF.

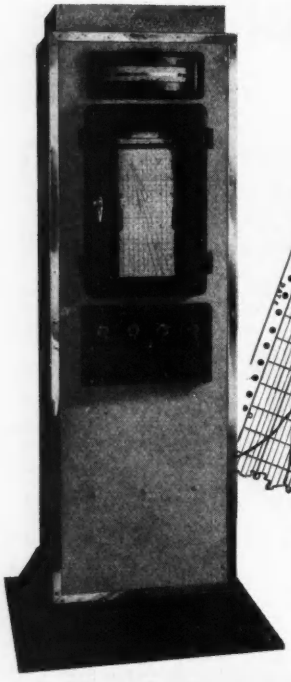
AIR FLOW 500 *cu. ft./min.*

Further details on request

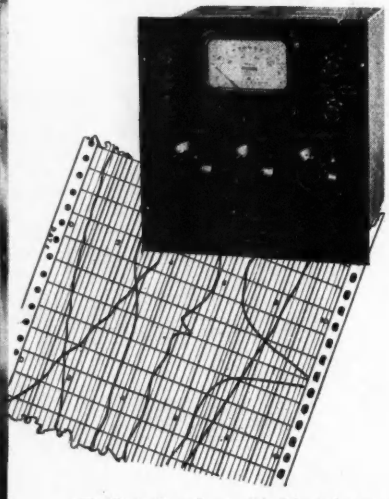
A catalogue giving details of other Ediswan Industrial and Special Purpose Valves will be supplied on request.

THE EDISON SWAN ELECTRIC CO. LTD., 155 Charing Cross Road, London, W.C.2.

(RM 65)



MULTI-POINT RECORDING AND INDICATING HIGH VACUUM



The unique features of the Edwards Pirani Type High Vacuum Gauges are now available in indicating and recording models for one to ten gauge heads.

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The illustrations show: (a) *A ten-point recording installation with a 10" edgwise indicating meter.* (b) *A six-point indicating instrument for panel mounting (also available bench mounted).*

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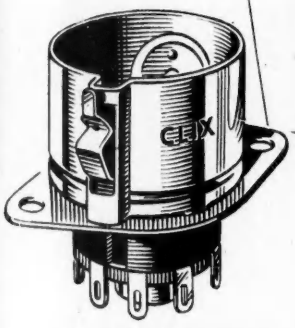
CLIX

B8A

VALVEHOLDERS



Clix valveholders are protected by British and Foreign Patents.

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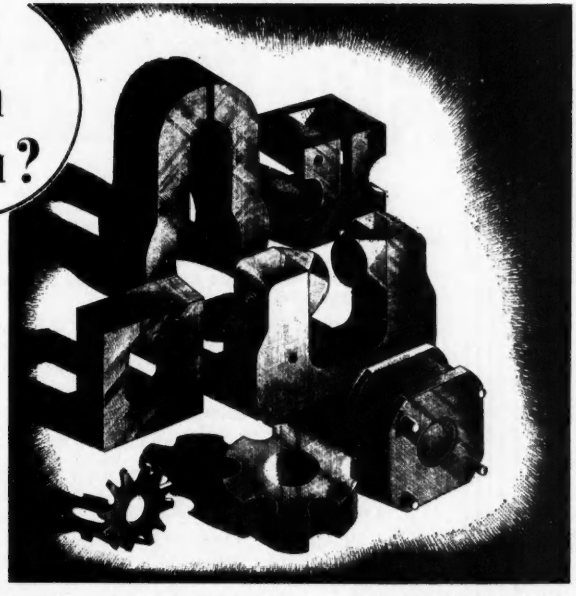

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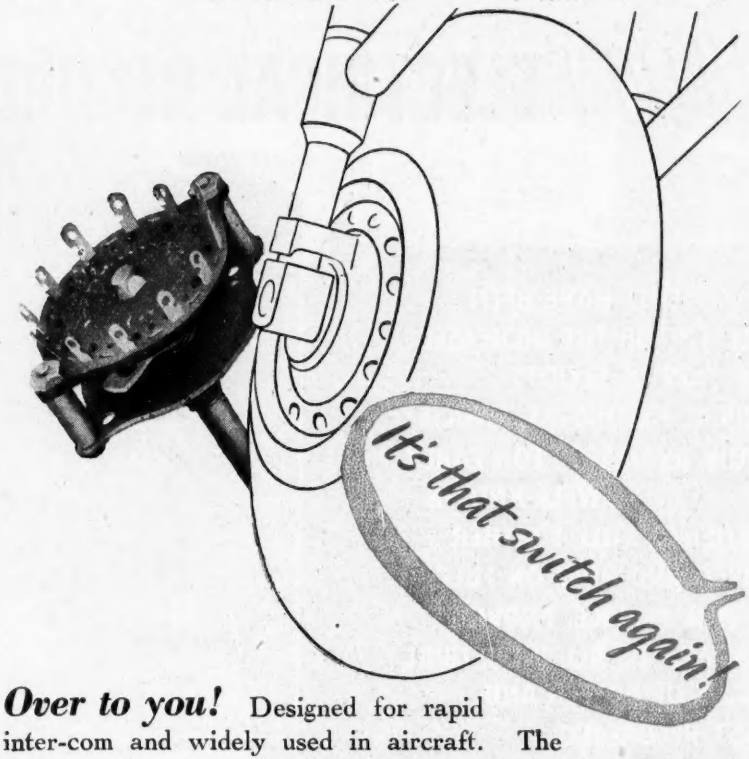

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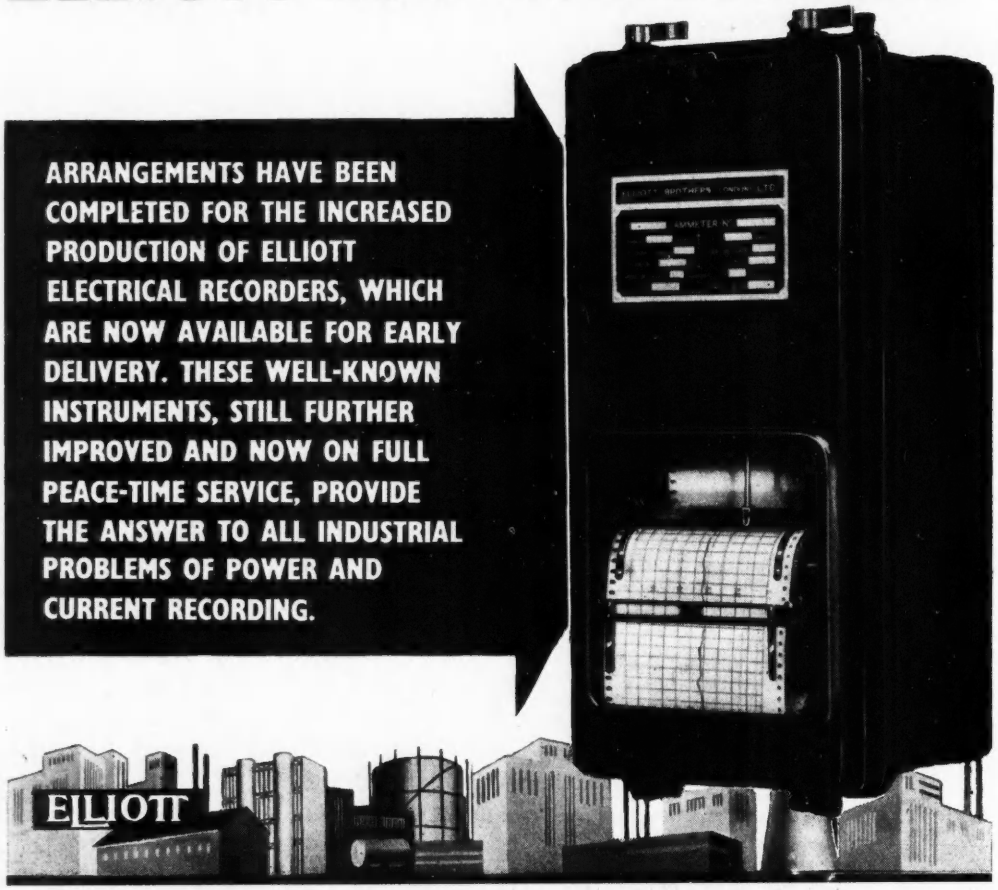

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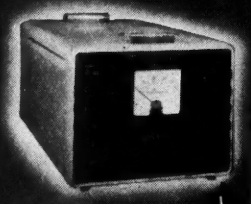
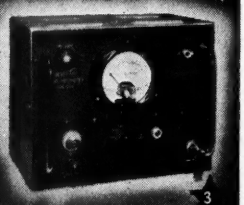
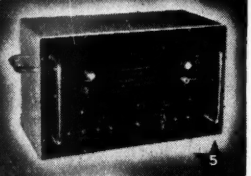
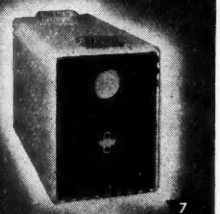
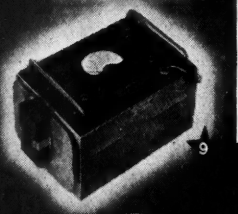
TEN INSTRUMENTS WHICH WILL FORM A LARGE PROPORTION OF FURZEHILL LABORATORIES LTD. PRODUCTION PROGRAMME FOR 1948

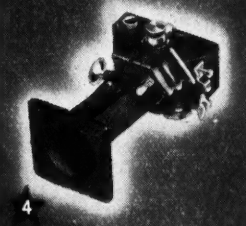


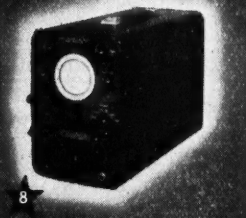












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★9 **DIODE VOLTMETER, Type 281B.** 50 c/s. 250 Mc/s. Accuracy ± 2% of f.s.d. Input impedance 4 megohms and 14 p.f. Price **£50.**

★10 **PORTABLE FREQUENCY STANDARD, Type 1100.** Outputs 1 Mc/s., 100 kc/s., 10 kc/s. Internal modulation 400 c/s. Usable up to 50 Mc/s. Accuracy ± 0.005%. Battery operated. Price **£25.**

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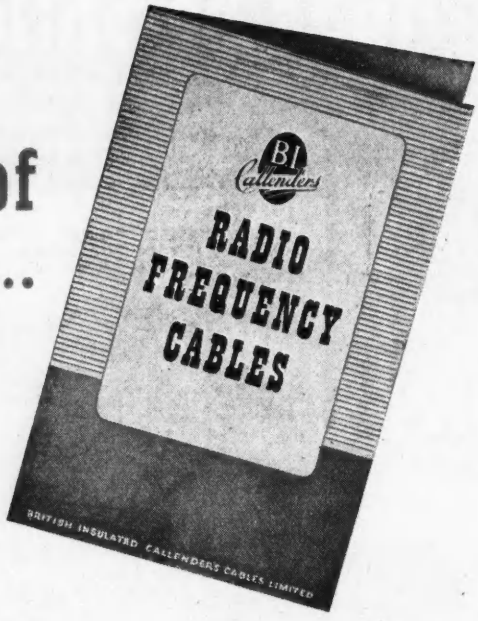
A matter of Balance...



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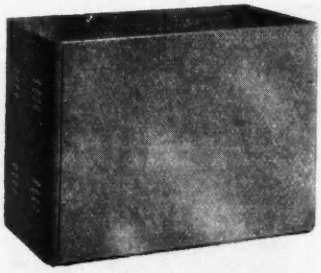

Shown is the Type 1022 case, of highest quality sheet steel, available in four sizes and finished in a variety of colours. Special features include pressed feet, front panels fixed by screws in hank-bushes, louvres at sides and in detachable back panel.

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Chassis and fixing brackets 15/- extra. Can be supplied with standard rack panels and hinged lid if required.

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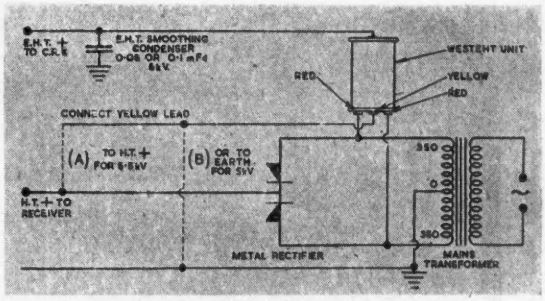

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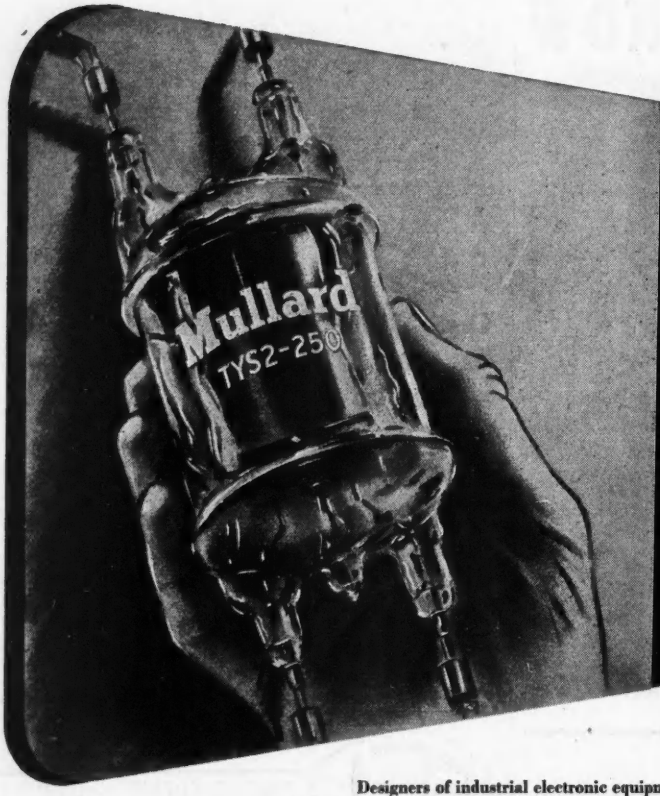

A Silica valve *as small as this gives you 550 watts output at a maximum frequency of 75 Mc/s*

Designers of industrial electronic equipment will find a wide field of application for the versatile TYS2-250. In addition to having the highest power-to-size ratio of any radiation-cooled valve in the world, the TYS2-250 is outstanding for its efficient performance at high frequencies, stable and high emission, uniform characteristics, and long working life. These features make it ideally suitable as a self-excited oscillator in low power R.F. heating equipments. It also offers considerable potentialities as an R.F. power amplifier in industrial or transmitting apparatus, and may in addition be used as a driver for higher powered valves.

Mullard engineers will be glad to advise on the wide applications of silica valves, the range of which includes the following types :—

VALVE TYPE	*MAXIMUM OPERATING FREQUENCY	OUTPUT POWER
TYS2-250	See panel below	
TYS4-500	50 Mc/s	1,500 W.
TYS5-2000	30 ,,	6,200 W.
TYS5-3000	30 ,,	10,000 W.
TX10-4000	20 ,,	9,700 W.

*The frequency figures shown are for reduced input; the power output figures for full input.

VALVE DATA—TYS2-250	
*Maximum operating frequency	75 Mc/s.
Output Power (as class C amplifier at 10 Mc/s) ...	760 W.
Max. Anode Dissipation	250 W.
Anode Voltage (50 Mc/s)	2,500 V.
Anode Voltage (75 Mc/s)	2,000 V.
Filament Voltage ...	6.5 V.
Filament Current	12.0 A. approx.

Mullard
THERMIONIC VALVES & ELECTRON TUBES

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Technical Training

IN the official account of the activities of the Telecommunications Research Establishment which appears on the next page, mention is made of the opening of a new School of Electronics, intended to train students of school-leaving age and fit them for appointments in the Establishment *and in the industry*.*

This new venture of a Government Establishment into the field of technical education is one which should be watched with interest by both students and teachers. Certainly, at the present time there is ample justification for providing additional facilities for technical training. The technical schools and colleges are overloaded and are likely to remain so for many years. The T.R.E. staff made a noteworthy contribution to the training of radar personnel during the war, and it is doubtless this success which has inspired the present scheme.

The statement reproduced on p. 207 refers to two classes of apprentices: craft apprentices for training as instrument makers, and engineering apprentices for training as *professional engineers*.*

Now there is, of course, ample precedent for specific apprenticeship training courses. Most of the big manufacturing organisations sponsor them, if they do not actually conduct them, and allow time off for attendance. The Ministry of Education approves such courses, as it has no doubt approved the T.R.E. training scheme. It is generally understood, however, that such courses are not intended to compete with the recognised courses of instruction given in the technical colleges in the county.

The training of the professional engineer follows on the lines originally laid down by Ayrton and Perry, Thompson, Walmsley, and other engineer-physicists who determined what is the best basic training for a student to become a useful member of the professional fraternity. After the groundwork has been established then he is free to specialise in telecommunications or radar, or whatever branch of engineering takes his fancy.

Under stress of war, this groundwork was frequently short-circuited with the results that we have already seen—the student realises that no amount of *ad hoc* training can prove a substitute for the real thing.

An important point on which the student will require assurance is: What is at the end of the course of training in a Government Establishment? If he decides that he does not wish to stay on in the service of the Ministry of Supply, is he at any disadvantage compared with his contemporaries who have gone through an orthodox training at a college or university?

The term of apprenticeship is five years—the same time as it takes a student to pass through college with an engineering degree or its equivalent, and to qualify as a Chartered Electrical Engineer after a few more years of practical experience.

When the full syllabus of the T.R.E. School appears, it is hoped that it will make it clear in what way the apprentice will be correspondingly qualified as a professional engineer.

The intake of the school is at present limited to 15 per class per year, so the new scheme will not make much impact on industry for the present. But all wedges have thin ends, and we may yet see articles signed "B.Sc. (M.o.S.)."

* Italics are ours.

T.R.E. *The Telecommunications Research Establishment at Great Malvern*

This Establishment, whose name and reputation are world-wide through its wartime activities, recently invited visitors to a 3-day exhibition of the developments which it is undertaking in radio and electronics

Centimetric Radar Sonde. This is a miniature self-contained radar station in a lightweight container which ascends to a height of 75,000 ft. The balloon then bursts and the instruments descend by parachute. During the flight, information on pressure, humidity, etc. is transmitted every 15 seconds.
The corner photograph shows a close-up of the recorders and transmitting equipment

T.R.E. is one of the largest research establishments on the Air side of the Ministry of Supply. While it retains its wartime responsibility for the development of radio equipment for the Royal Air Force and Naval Air Arm, T.R.E. is now responsible also for the development of radio aids for Civil Aviation and for a programme of research in radio and electronics, part of which is sponsored by the Department of Scientific and Industrial Research.

The establishment is organised into three main technical departments : Radar, Physics, and Engineering.

Radar Department

The main objective of the Radar Department is to design, with a view to production, radar and pulsed radio navigational aids for military and civil aircraft.

The radar bomber with its H$_2$S equipment for locating targets and A.G.L.T. (Airborne Gun Laying Turret) for detecting enemy fighters and directing guns is an example of equipment designed specifically for military use.

Another example is given in the night fighter with its A.I. (Aircraft Interception) radar equipment which can locate bomber targets at night or in conditions of bad visibility, and present on the windscreen the position the enemy would assume were it visible to the human, as well as the radar "eye."

The problems of Civil Aviation are closely related to those military problems on which T.R.E. worked during the war. Techniques developed during the war for locating aircraft are being applied to solving the problem of long- and short-range air traffic control (Airfield Control Radar) and new equipments such as the Airfield Surface Movement Indicator are being devised to give a picture of an airfield under all conditions of visibility.

Meteorological investigations carried out in collaboration with the Physics Department have made it possible to design an equipment (Cloud and Collision Warning) which can detect dangerous cumulonimbus clouds and high ground by night and day.

Physics Department

The Physics Department is concerned with fundamental and basic research in radio and electronics, rather than the design of specific equipments for military or civil use. Examples of the type of work carried out are research into the properties of very short waves, infra-red radiation, and investigations in the field of electronics.

The main problem in the infra-red region is to devise fast and sensitive detectors in the "long" infra-red region (5-15μ). Already this work has proved of great commercial value in the very fast detection of "hot spots" in brake linings, and may ultimately provide a means of producing heat pictures when ordinary light pictures are impossible, *i.e.*, in the dark.

Fundamental work on electronics is illustrated by the magnetic D.C. amplifier which can detect a signal of 10^{-15} watt and the electronic digital computer which can remember numbers and carry out mathematical operations in a fraction of a second. An interesting application of servo motors is found in the automatic following telescope. It has been successfully demonstrated at Greenwich Observatory that this system will enable a telescope to follow a star at night quite automatically without any external assistance.

Engineering Department

The Engineering Department provides the bridge between the scientific staff and commercial production. Preliminary work on drawings and experimental equipment is carried out in drawing offices and small workshops situated in each experimental block. The Engineering Unit carries out constructional work on the final experimental model, the full drawings being prepared in the Main Drawing Office attached to the Engineering Unit.

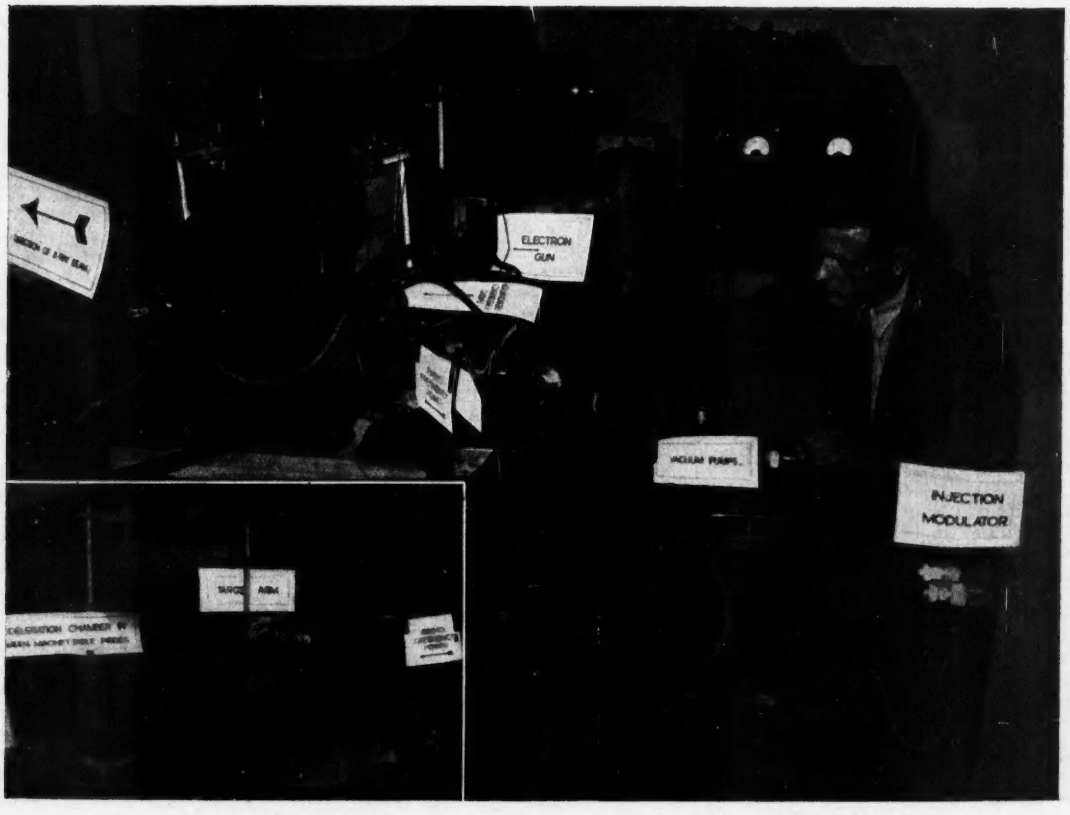
T.R.E. is also responsible for the packaging of equipments and spare components so that they can withstand the rigours of Arctic winters as well as the high humidities and temperatures of tropical regions.

School of Electronics

The Ministry of Supply has now launched a comprehensive apprenticeship scheme, the object of which is to provide technically trained personnel for the Ministry and for Industry. The Ministry of Supply School of Electronics has been established at T.R.E. and was officially opened on Thursday, May 27.

Two classes of apprentices are being trained—craft apprentices for training as instrument makers, and engineering apprentices for training as professional engineers. Both serve a five-year apprenticeship, and the annual intake is about 15 in each class. Engineering apprentices are selected by the Civil Service Commissioners on the results of a competitive examination, while craft apprentices are recruited locally by competitive interview and aptitude tests.

Two views of a 15 MEV Synchrotron demonstrated at the exhibition



An Ultrasonic Memory Unit for the EDSAC

By M. V. WILKES, M.A.*
and
W. RENWICK, B.Sc.†

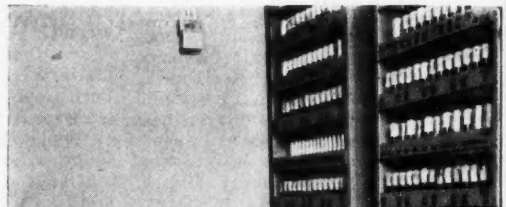


Fig. 5. General view of the computer racks with a completed battery of delay units in the foreground

Introduction

THE successful completion of the ENIAC by the Moore School of Electrical Engineering in Philadelphia marked a new stage in the application of electronic devices to computing.[1,2] This machine suffers, however, from two major drawbacks: its great complexity—it contains in all 18,000 valves—and its very limited memory capacity. The latter defect, although unimportant when solving the ordinary differential equations for which the machine was primarily intended, seriously limits its sphere of application. In order to deal with problems in partial differential equations, for example, one really needs storage capacity for hundreds or even thousands of numbers.

These limitations of the ENIAC were clear to the designers and even before it was finished a second project, for a machine known as the EDVAC (Electronic Discrete Variable Automatic Calculator), was being discussed. One of the authors was privileged to study the plans for this project in August, 1946, when he attended the latter part of a course on electronic computing machines at the Moore School; in this connexion he is especially indebted to Dr. John Mauchly, Dr. J. Presper Eckert, Dr. Herman H. Goldstine and Dr. T. K. Sharpless.

The EDVAC is now in course of construction and a machine on similar lines is being built in the University Mathematical Laboratory at Cambridge. This latter machine is known as the EDSAC (Electronic Delay Storage Automatic Calculator). Although it is not yet complete, two units of the memory have been built. The memory is the central part around which the machine is constructed, and as its design presents many problems of interest to electronic engineers, it is thought that a description of its main features may be of interest in advance of the completion of the whole machine.

The same type of memory is being used in the EDVAC and some information about it has already been published.[3,4]

General Principles

There are many advantages in designing a calculating machine to work in the scale of two. In this scale there are only two digits, 1 and 0, and numbers therefore lend themselves to representation by a train of pulses, the presence of a pulse indicating a "1" and the absence of a pulse a "0." Fig. 1 will make this clear. This system is adopted for the EDSAC and all internal operations in the machine are carried out in the scale of 2. The machine will, however, accept numbers in the scale of 10 and carry out the necessary conversion to the scale of 2 automatically; it will similarly convert output data into the scale of 10 before printing takes place. Users need not therefore take any account of the fact that the machine itself works in an unfamiliar scale.

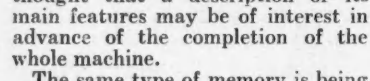


Fig. 1. Representation of binary digits by presence or absence of pulses. The binary number 1101 is equivalent to 2^3+2^2+0+1, i.e., 13 in decimal notation

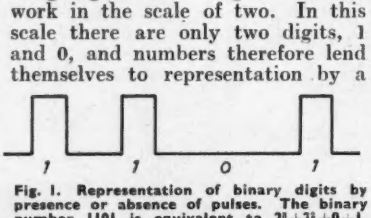


Fig. 2. Regeneration and circulation of pulses in delay unit

The programme of operations to be carried out by the machine is broken down into a series of orders, each of which represents an elementary arithmetical or transfer operation. These orders are expressed in code form as a train of pulses and are stored in the memory until required, in exactly the same way as numbers.

The memory system depends on the use of a device, by means of which a train of pulses may be delayed for a time interval longer than the duration of the train. The pulses are passed into the delay device and when they appear at the output terminals are amplified and routed back to the input. They are thus kept in circulation for an in-

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definite length of time and can be taken out when required. It will be noted, however, that a given group of consecutive pulses is not, in general, available at once, since it is necessary to wait until it emerges from the delay. This disadvantage is fundamental to the present type of memory and cannot be avoided.

The system as described above is open to the objection that the pulses would suffer some deterioration in waveform at each passage through the delay unit, the cumulative effect of which would be fatal to the correct functioning of the device. This difficulty is avoided by modifying the system in the following manner: Instead of being passed direct to the input of the delay unit, the outcoming pulses are applied after amplification to an electronic gate circuit which controls the passage into the delay unit of pulses (known as clock pulses) from a continuously running pulse generator. Each time a pulse appears at the output of the delay unit, a clock pulse is allowed to pass into the input; if no pulse appears, no clock pulse passes into the input. The result is exactly the same as if the pulses were circulating continuously, but they are, in effect, renewed at each passage and successive deterioration of shape is avoided. The arrangement is shown in diagrammatic form in Fig. 2.

Ultrasonic Delay Unit

The delay system used may now be described. It makes use of the fact that ultrasonic waves in liquids travel at speeds which are slow on the time scale on which electronic events can be made to occur, so that it is possible to delay a train of pulses for a comparatively long time by converting them into pulses of ultrasonic sound and passing them down a column of liquid a few feet long. The conversion is conveniently done by means of an X-cut quartz crystal, and an exactly similar crystal can be used at the far end of the tube to convert the ultrasonic pulses back into electrical pulses.

Before being applied to the transmitting crystal, the pulses are modulated on to a carrier wave of frequency 13.5 Mc/s. The crystals are cut to resonate at this frequency when unloaded. Modulation is 100 per cent. in the sense that the amplitude is zero between pulses. The pulses picked up by the receiving crystal are amplified, shaped and used to control the passage of clock pulses in the manner described above. Gating circuits are provided for input and output so that numbers circulating in the delay tube may be cleared when no longer required. The schematic diagram of a unit is shown in Fig. 3.

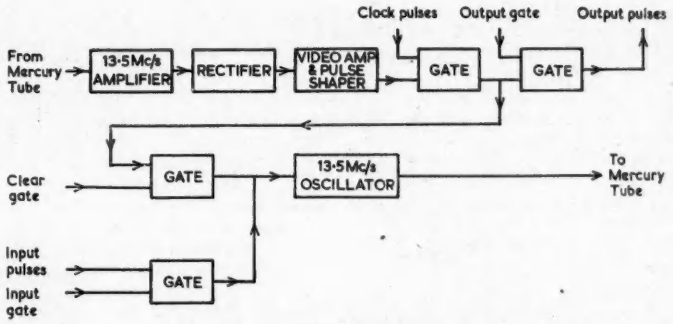


Fig. 3. Schematic diagram of memory unit

The storage capacity of an ultrasonic memory system depends on the length of the liquid column and the time interval between successive pulses. In order to make maximum use of a given length of liquid and therefore of a given overall delay it is clearly desirable to use pulses which are as short as possible. On the other hand the use of pulses appreciably shorter than 1 μS raises very difficult technical problems, and some compromise is necessary. In the EDSAC, the pulses are approximately 0.9 μS long, and the minimum interval between the end of one pulse and the beginning of the next is 1.0 μS. It may be mentioned here that the standard amplitude for pulses throughout the machine is about 18 volts.

For mathematical reasons which are outside the scope of this article, it was decided to make provision for 34 binary digits in each number. In the decimal scale this corresponds to about 10 digits. One additional digit is required to represent the sign, so that 35 consecutive pulses or blank spaces are needed to specify a single number. It is convenient to allow a space equal to one pulse length between consecutive numbers so that the total length of a number is increased to 36 pulses. This interval is sometimes referred to as a minor cycle, a term originally introduced by Dr. von Neumann of the Institute for Advanced Study, Princeton.

Choice of an Ultrasonic Delay Medium

The ultrasonic delay units described in this paper are filled with mercury. There are a number of reasons why this is the most suitable liquid to use, although if necessary satisfactory results could no doubt be obtained with other liquids. In the first place the acoustic impedances of mercury and quartz are similar, so that there is no difficulty in loading the crystal adequately and thereby ensuring good energy transfer with sufficient damping of the crystal to give the required bandwidth. Moreover, the temperature coefficient of variation of velocity of sound in mercury is fairly small over the range of temperatures usually found in a laboratory. It is not therefore necessary to keep the tubes at any particular temperature, but only to ensure that they are all within, say, $\frac{1}{2}$° C. of the same temperature. The frequency of the clock pulses must in this case be controlled electronically by one of the delay tubes so that the time of circulation of pulses is equal to the correct number of clock pulse intervals. An alternative way of proceeding would be to keep the mercury tubes within close temperature limits by means of a thermostat and to use a crystal controlled oscillator. This method is not, however, being used in the EDSAC.

A final advantage of mercury is that it is not corrosive and the tubes can be made of mild steel. It is, of course, necessary to keep the mercury away from all brass parts.

Mechanical Construction

The wavelength in mercury which corresponds to the carrier frequency of 13.5 Mc/s. is about 0.004 in.; this is very small compared with the diameter of the active area of the

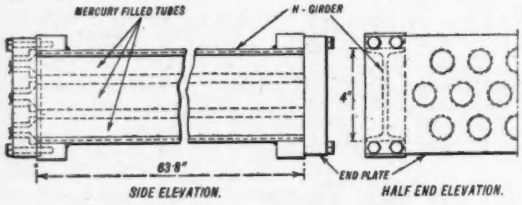


Fig. 4. Construction of battery of mercury tubes

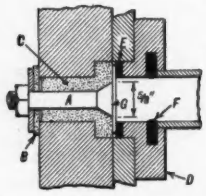


Fig. 6. Assembly of tube and end plate

A = brass electrode
B = Paxolin washer
C = Tufnol insert
D = steel collar
E = rubber washer
F = captive rubber washer
G = quartz crystal (.009 in. thick)

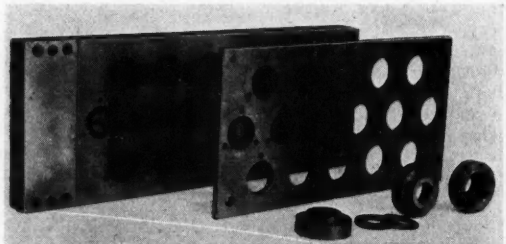


Fig. 7. End-plate assembly of battery. The upper photograph shows the exploded view. The screening cans seen in this photograph have since been replaced by the type shown in Fig. 5

crystals ($\frac{3}{8}$ in.) and it follows from considerations similar to those familiar in geometrical optics that the crystals must be parallel to one another to within about 3 minutes of arc. For this reason a very rigid structure and accurate machining are required.

Fig. 4 is a sketch showing the form of construction adopted for the battery and Fig. 5 is a photograph of an assembled unit. The crystals are located against two plates of steel 1 in. thick, the surfaces of which are ground flat. These plates are held parallel to within an accuracy of better than 0.001 in. and at the correct distance apart by two 4-in. H-girders which have accurately-machined ends. The mercury tubes themselves are held in position between the end plates in the manner shown in Fig. 6.

The mercury itself provides electrical connexions to the front surface of each crystal, while connection to the rear is made by means of a brass electrode A which is let into the end plate and insulated from it by a Tufnol insert C and a Paxolin washer B. The final grinding of the end plates is not done until the electrodes have been inserted.

In the memory system being described, each tube is arranged to hold 576 pulses or 16 minor cycles. Since a memory capacity of at least several hundred numbers is required in the complete machine, it will be seen that many separate tubes are required. In the case of the EDSAC these are built in batteries of 16, each battery therefore holding 256 numbers. Two such batteries have been constructed and further batteries will be added as required.

The figure of 16 for the number of minor cycles in a single delay tube was chosen partly because it is a power of 2, and is therefore convenient from the point of view of switching operations, and partly because the resulting length of tube (about 5 ft. 4 in.) lends itself to sound mechanical construction. Also the use of very much longer tubes would have given rise to excessive attenuation. Similar considerations led to the decision to build the tubes in batteries of 16.

It may be mentioned here that the minute air gap which always exists between surfaces in contact, even though they have been ground flat, serves to prevent the passage of ultrasonic energy backwards from the crystal into the brass. This is because of the very large acoustic mis-match between air and brass, and between air and quartz. If this gap becomes filled with some liquid, such as oil, which wets both surfaces, it no longer acts as an acoustic insulator, and a serious loss of performance occurs. Some trouble was experienced at first on account of small quantities of oil trapped in the minute space between the brass electrode and the Tufnol insulator being drawn out by surface tension into the gap between the crystal and the brass electrode. This can be avoided by dipping each brass electrode into shellac varnish before assembly, so that the space between it and the Tufnol insulator is filled. As a further precaution, the use of oil should be avoided when turning the Tufnol insulators.

Each crystal is kept firmly in contact with the corresponding electrode by a steel collar, D (see Fig. 6), and a rubber washer, E, the latter forming a mercury-tight seal. The collar also contains a captive rubber washer, F, against which the end of the steel tube fits, and which forms a second mercury-tight seal. This form of construction gives an extremely rigid structure and makes assembly easy; at the same time the number of parts which have to be machined to a high degree of precision is reduced to a minimum.

Fig. 7 is a photograph of some of the component parts of an end plate assembly, and also shows an assembled end plate.

Assembly and Filling

Before assembly the tubes and crystals are carefully cleaned with carbon tetrachloride, as any dirt or dust tends to find its way to the surfaces of the crystals and impair operation. In the ordinary way mercury does not wet quartz, and in consequence there is a tendency for a thin film of air to be trapped between the mercury and the crystal. As in the case of the air gap behind the crystal, this has the effect of reducing transmission to a very low level. One way of getting over this difficulty would be to use chemically pure mercury and to pay careful attention to cleaning the surface of the quartz crystals; if this is done, mercury can be made to wet quartz. A better method, however, is to fill the tube first with some other liquid such as alcohol which wets both quartz and mercury. When the mercury is poured in, the alcohol is displaced and a thin film left on the surface of the crystals. This film is too thin to have any appreciable effect on the performance except that it acts as a bridge for the passage of acoustic energy. An experimental tube filled in this way has been in use for over a year and shows no sign of falling off in performance.

It was at first thought that the use of commercial mercury from which the bulk of the oxidisable impurities had been removed by a chemical method would give satisfactory results. Experience has shown, however, that the velocity of ultrasonic waves in different samples of mercury prepared in this way can differ by as much as 0.1 per cent. The effect is presumably due to remaining impurities, and for this reason it is best to fill the battery with double-distilled mercury.

The battery of tubes is placed in a welded steel tray which collects the alcohol displaced during the filling operation and any mercury which may overflow.

The crystals are connected to the electronic equipment by means of coaxial cables of 70 ohms impedance, and screening boxes attached to the ends of the battery contain the necessary matching circuits. These are very simple, each consisting of a 68-ohm resistance in series with a coil which tunes out the crystal capacity. Good screening at the end of the tubes at which the signal level is low is essential in order to avoid pickup of stray pulses radiated by electric motors and other laboratory equipment.

Circuits

An important aspect in which an electronic calculating machine differs from most other applications of pulse technique is that many of the waveforms are not repetitive. For example, at one moment a memory tube may be storing a number which consists of a continuous train of pulses and at the next moment this number may be replaced by one which contains a few pulses only, or even no pulses at all. As a result it is necessary to provide D.C. restoring diodes at every point in the circuit where there is a capacity resistance coupling, in order to prevent changes occurring in the D.C. level. The result is that D.C. restoring diodes make up an appreciable fraction of the total number of valves in the machine.

A typical gating circuit, or electronic switch, is shown in Fig. 8. The two inputs are applied through cathode followers V_1 and V_2 to the cathodes of diodes V_3 and V_4, the anodes of which are connected together and taken up to H.T. positive through a resistance R. Since the output impedances of the cathode followers are low compared with R, the anodes of V_3 and V_4, and hence the grid of the output cathode follower, can only rise in potential if the grids of both V_1 and V_2 rise; the output potential then follows that of the grid of V_1 or V_2 whichever is the lower.

Thus if a train of pulses is applied to the grid of V_1 and a positive going square wave to the grid of V_2, the pulses will appear at the output for as long as the square wave lasts, but will cease to pass as soon as the grid of V_2 returns to zero. Alternatively, two trains of pulses may be applied to each grid; a pulse will appear at the output when there is a pulse in each input, but not otherwise.

In practice there is a slight "break-through" when a pulse is applied to one grid only, the other being held at zero potential. This arises because the output resistances of the cathode followers V_1 and V_2 are not zero, and because the resistance of a diode in a conducting condition is also not zero. In the memory system being described, EB34's (double diodes) are used for the diodes, and EF54's (RL7's), connected as triodes, for the cathode followers. In this case the break-through amounts to about 13 per cent. for an applied pulse of 20 V peak amplitude, and the overall loss suffered by a pulse passing through the circuit is about 2 db. In certain cases, when break-through from one particular input is especially undesirable, it may be possible to arrange that the zero level for this input is slightly above that of the other. Break-through of pulses appearing on this input will not then occur, although break-through of pulses on the other input will be somewhat increased.

The performance figures given above are quite adequate for the circuits associated with the mercury units. In certain other parts of the machine, however, diode gates using EA50's are being used. If the resistance R is increased to 100 KΩ and the cathode resistors reduced to 1 KΩ the break-through is then only 8 per cent.; the transmission loss is still about 2 db.

The circuits used in association with the mercury tubes will now be described.

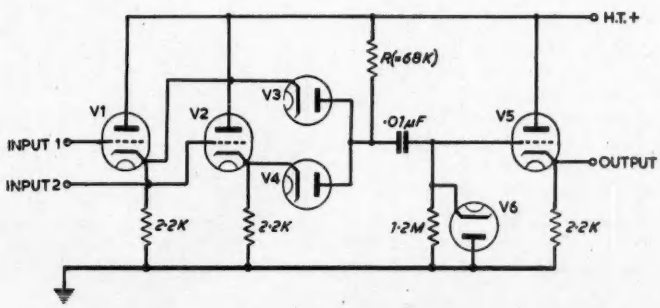


Fig. 8. Typical gate circuit

Fig. 9 shows the way in which pulses are modulated on to a 13.5-Mc/s. carrier before they are passed to the transmitting crystal in the delay tube. V_1 is an electron-coupled oscillator which is normally prevented from oscillating by V_2 which acts as a damping valve, its cathode impedance $(1/g)$ being connected across the tuned circuit. The incoming pulses of amplitude 18-20 volts are applied to the grid of an amplifier (V_3) which is biased back by about 10-12 volts in order to provide protection against spurious pulses entering the system from outside. When V_3 conducts, its anode potential falls and V_2 is cut off. The damping impedance is therefore removed from the tuned circuit, and V_1 begins to oscillate. In order that it should cease to oscillate promptly when the applied pulse ceased, it was found necessary to include an extra damping resistance (2.2 KΩ) in the cathode circuit of V_2.

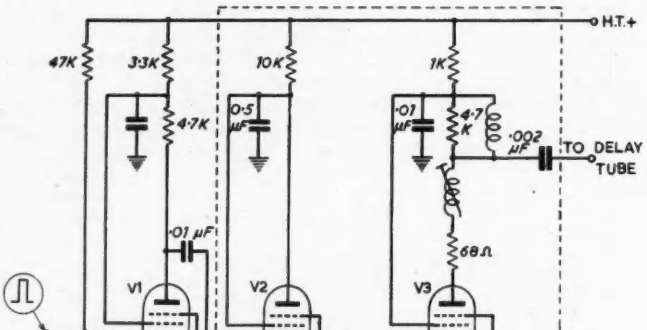


Fig. 9. 13.5 Mc/s oscillator circuit

R.F. pulses from the anode of V_1 are fed to the delay tube through a length of 70-ohm coaxial cable. Correct matching is achieved by the circuit shown which presents a parallel tuned circuit to the valve, and a series tuned circuit to the cable.

Details of the circuit used to amplify and regenerate pulses which have passed through a delay tube are given in Fig. 10. The R.F. pulse input to the transmitting crystal at 70 ohms is about 25 volts peak, and the loss resulting from transmission down the column of mercury together with the conversion loss at the crystal is about 68 db. The output from the receiving crystal at 70 ohms is therefore only about 10 mV, and two stages of R.F. amplification are provided before rectification.

It was decided after some consideration to design the system to have a bandwidth of 1 Mc/s. at 3 db. down (1.5 Mc/s. at 6 db. down). This is not sufficient to preserve the shape of the pulses, and they are lengthened to slightly less than 1.9 μS, *i.e.*, each pulse just fails to overlap the following pulse. In order to avoid difficulties with D.C. restoration, it is necessary to ensure that after rectification there is always a clear interval between pulses: this is done by applying a steady bias to the rectifier, so that only the tops of the pulses are able to pass through. This bias is arranged to be adjustable by means

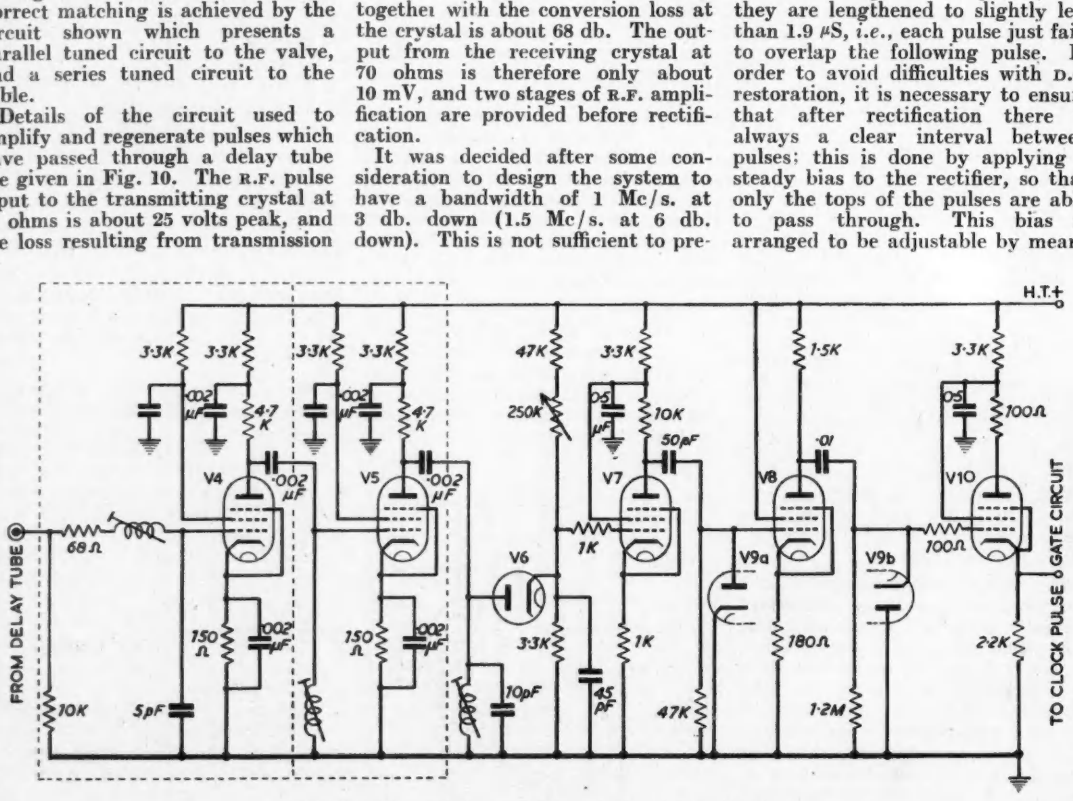


Fig. 10. R.F. amplifier, rectifier and pulse-shaping circuits

of a variable resistance, and this control takes the place of a gain control. The bias acts as an additional safeguard against the entry into the system of interfering signals from outside.

As an alternative, the system might have been designed to pass pulses without appreciable lengthening; a bandwidth of something like 4 Mc/s. would have been required for this purpose. While this would have been entirely practicable, the signal level at the input of the amplifier would have been lower, and an additional stage of amplification would have been necessary.

After rectification the pulses are passed into two shaping stages, one having a short time constant C-R coupling. The output pulse, which is between 1.6 and 1.8 μS long and about 28 volts in amplitude, is used to gate clock pulses. Since the clock pulses are only 0.9 μS long, there is an overlap of between 0.7 and 0.9 μS. This provides sufficient tolerance to allow for slight differences between units, variation of clock pulse frequency, etc.

Short Tubes

In addition to the long tubes comprising the main memory batteries, there will be a requirement in the control and computer units of the EDSAC for short tubes giving delays of length 1 minor cycle and ½ minor cycle. A sketch showing the mode of construction of one of these tubes is given in Fig. 11, together with a photograph of an assembled unit.

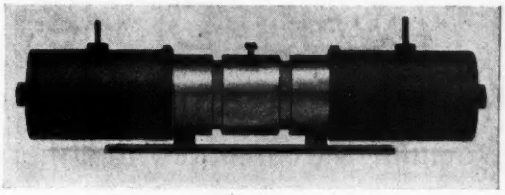
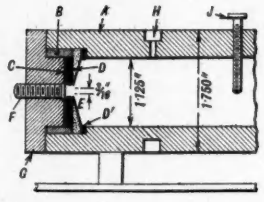


Fig. 11. Short tube, with sketch of its construction
A = steel tube
B = Tufnol sleeve
C = quartz crystal
D & D' = rubber washers
E = bevelled, sandblasted, mild steel washer
F = brass electrode
G = Tufnol plug
H = filling and expansion hole
J = steel plunger



It will be seen that the diameter of the active area of the crystal is only 3/16 in. compared with ⅝ in. in the case of the long tubes, and that it is surrounded by a bevelled and sandblasted washer. This is in order to reduce the amplitude of pulses which are reflected at the surfaces of the crystals and which makes several passages of the tube before entering the amplifier. As a further measure to this end, a 4 B.A. screw is inserted in the middle of the tube (along a diameter); this acts as a baffle, and causes a certain loss of energy at each passage of the pulses. Similar devices are unnecessary in the case of the long tubes, since the attenuation in the mercury is sufficient to reduce to a negligible amplitude pulses which pass more than once along the tube.

Acknowledgments

The authors would like to acknowledge gratefully much advice on the design and handling of mercury delay tubes which they have received from Mr. T. Gold. They are also greatly indebted to Mr. P. J. Farmer and other members of the laboratory staff for their enthusiastic assistance.

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Portable Wire Recorder

THE Webster-Chicago Model 80 is a self-contained, portable magnetic wire recorder and player. It is sold complete with microphone and three spools of wire, two ¼-hour and one ½-hour.

The wire is 0.004 in. diameter and runs at a speed of 2 ft./sec. for recording and 14 ft./sec. for rewinding, the driving motor being of the 4-pole, shaded-pole induction type. A single recording head is used for recording, playing and erasing. Four valves are used in the apparatus, three as amplifiers and one as a rectifier. Tone and volume controls are fitted and there is a built-in 5¼-in. loudspeaker, also an output socket.

The price in America is about £38. Makers: The Webster-Chicago Corp., 5610 Bloomingdale Avenue, Chicago 39, Illinois, U.S.A.

Power Diodes

Part 1. The Design of High Vacuum Oxide-coated Rectifiers

By

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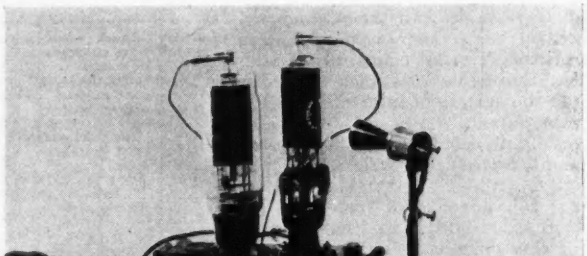


Fig. 5. Micro-thermopile set up for anode dissipation measurements

VALVES used in rectifier circuits may be high vacuum, mercury vapour, mercury arc, or hot cathode gas-filled. Each type has its specific uses for which it is preferred over and above other types, but this article is limited to high vacuum types having oxide-coated cathodes.

As is well known, the ideal diode is one in which the internal voltage drop is zero. Mercury vapour valves closely approximate to this ideal, while high vacuum types fall much shorter of this condition. For this reason, among others, it has been customary to confine the high vacuum valves to low current applications, but the need for valves to operate in any mounting position and under wide ranges of temperature and humidity has led to the design of high vacuum valves for regions usually covered by mercury vapour types. High vacuum oxide-coated rectifiers now exist for ratings up to 3 KV D.C. at 250 mA output and up to 30 KV D.C. 250 μA D.C. output.

Summary of Design Procedure

It is the aim of valve manufacturers to design and produce valves which have a good efficiency and which will give a satisfactory life with reliability during that life. The good efficiency requirement is primarily the responsibility of the valve designer, but life and reliability during life depends not only upon satisfactory design but on factors which are influenced by the ability of the manufacturing personnel and the quality of the manufacturing plant.

Valve design usually starts from a known requirement which is finally met by joint processes of theoretical calculation, the use of previous experience and the practical testing of experimental samples. The calculations used are generally of a semi-empirical nature, while experience on numbers of existing types which are known to be satisfactory has enabled the designer to collate design data in the form of empirical formulae or design charts which simplify the basic calculations.

Before starting work on a new rectifier the designer requires to know the output desired in voltage and current, which information he has to interpret into the primary parameters of peak current, anode dissipation and peak inverse voltage.

The peak current requirement settles the rating of the cathode which may be directly or indirectly-heated, dependent on the particular application, and the wishes of the customer.

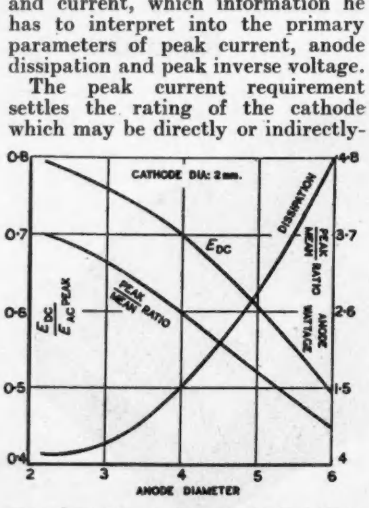


Fig. 1. Peak/mean ratio, anode dissipation, and output voltage against anode diameter

The anode design is essentially a compromise to accommodate the conflicting needs of D.C. output voltage, peak anode current, manufacturing clearances and total anode dissipation. As shown in Fig. 1, the output voltage possible falls with an increase in the minor axis of the anode, while the anode dissipation rises rapidly.

At this stage the valve design has to be carefully reviewed from the standpoint of the maximum peak inverse voltage, which function bears no clearly definable relationship with the mechanical considerations dictated by current and dissipation, and it is often the case that the ultimate detailed design of the valve is governed almost entirely by voltage considerations. The use of "pinch ears," "nib seals," ceramics, bulb locating devices, guard wires and the shielding of insulators are all dictated by the peak inverse voltage.

The external dimensions of the finished valve are determined by voltage and anode dissipation requirements. The envelope size has to be adequate to give sufficient voltage flashover clearance between the anode and cathode terminals and to dissipate safely the heat generated in the valve. The present tendency to totally enclose equipment and to use such equipment at high ambient temperatures makes it necessary to

* The M. O. Valve Co., Ltd.

pay particular attention to this part of the design. Finally, it should be appreciated that valve design is closely related to economics and it is desirable to employ parts which are standard to other types already tooled, while the quantity needed may call for particular types of manufacturing plant.

At this stage practical samples have to be constructed and further modifications are then carried out as a result of tests made on actual valves.

Definitions

There are certain rectifier parameters that can be defined. These are:

The peak current. This is the maximum current passed by the valve during the conducting cycle and is limited by the applied voltage and the total impedance of the circuit.

The mean current is the average value of the unidirectional current wave measured over the whole cycle. This latter is limited mainly by the load circuit impedance.

The switching current is the surge measured at the instant of switching and as it is limited solely by the source resistance of the circuit it can under some circumstances be as great as twenty times the mean current.

The peak/mean ratio is the ratio of the peak to mean currents.

The peak inverse voltage is the voltage which normally appears across the valve during the non-conducting cycle. It is usually equal to 1.4 times the input voltage plus the output voltage, but is often greater.

The anode dissipation consists of the normal impedance losses together with any power radiated to the anode from the cathode system.

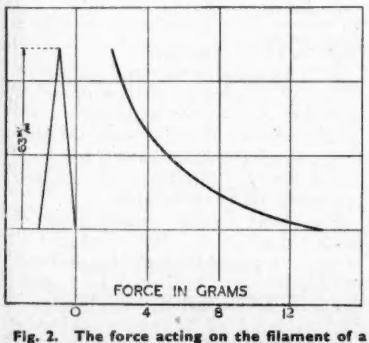


Fig. 2. The force acting on the filament of a U.19 rectifier when running at full load. Peak inverse volts, 14.5 kV

Detailed Design Considerations

General

As stated earlier, the design of a rectifier for a specific purpose is governed by the mean rectified current required and the desired input and output voltages of the circuit. These basic parameters control the values of peak/mean current ratio, peak inverse voltage and total charging resistance. The design of a valve to meet these requirements starts with a consideration of the cathode system:

Cathode Area and Temperature

The operating temperature for the cathode has to be chosen so that there is adequate emission life and this determines the current density which can be employed. This is true for all emitters, the working temperature range of each material being different and the satisfactory "band width" comparatively small, the range for oxide-coated cathodes being 950° - 1,150° K. Different manufacturers design at varying points in this band. American practice seems to favour hotter cathodes than are normally used in this country, their valve cathodes being operated at 1,055°-1,150° K. corresponding to 3-4 watts per sq. cm. of radiating cathode surface. In our Company, experience over many years has shown that for all oxide-coated rectifier cathodes a design figure of 2.5 watts/cm² of cathode surface corresponding to a temperature of 1,020° K. represents an effective compromise between adequate peak current reserve, consistent quality in manufacture and satisfactory life.

Type of Cathode

Valves may have directly or indirectly heated cathodes. *Directly heated types* have fewer components and are therefore cheaper to manufacture, while indirectly heated types are mechanically more robust and because they have cathode heating times similar to other valves in the circuit, thereby mitigate high switching voltages on the condensers. Directly heated cathodes usually operate at peculiarly low filament voltages, because a reasonable length valve system is limited to 2-3 volts per filament "Vee." Both wires and strips are used, strips being favoured for higher filament currents because the length can be shorter for an equivalent rating.

Even the thickest strips and wires used as cathodes are weak mechanically and it is necessary to support them, usually by a cantilever or helical spring hooked on to the centre of the "Vee" formed by the filament. During the reverse cycle the electrostatic pull exerted on the filament tends to displace it, some idea of the forces existing in practice being shown in Fig. 2. This pull is rhythmic, and sets up vibrations which can destroy the filament if it in insufficiently rigid. Thus the filament has to be tensioned such that its vibration is damped without stressing the metal to the yield point. Extensive life test and practical experience has shown that for the safe running of nickel at 1,020° K. the maximum permissible tension must not exceed 100 gm/mm².

For *indirectly heated valves* the choice of cathode is independent of heater rating but it is usual to employ standard cathode sizes as used in other valve types but running them at 25 per cent. increase in wattage on normal valve types. Circular cathodes and concentric systems are simpler to make and more consistent in mechanical tolerances and are therefore used where the anode to cathode clearance is small and the cathode wattage not greater than 4 watts.

Fig. 3 shows various means of locating the cathode in the mica supports.

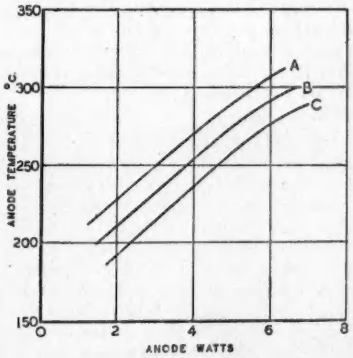
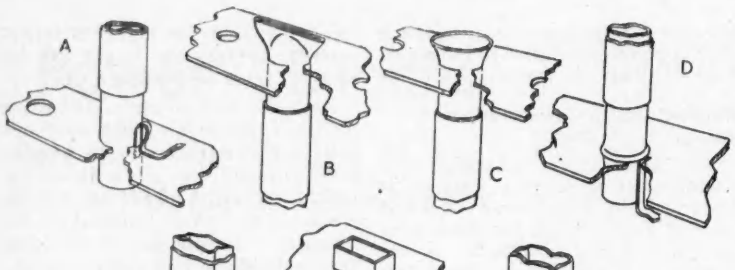


Fig. 6. Curves showing the effect of anode and filament wattages on anode dissipation. A = 4.5 W B = 4.0 W C = 3.5 W



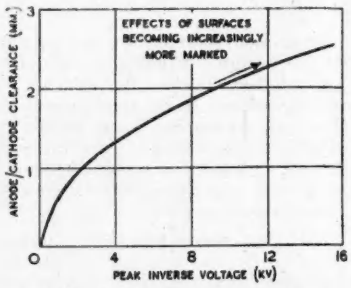


Fig. 4. The effect of anode/cathode clearance on the maximum permissible safe peak inverse voltage

Fig. 3. (Left) Various methods of cathode location

A. Metal tag pushed down on to the mica.
B. Cathode squeezed flat to enlarge the diameter.
C. Cathode end belled out to enlarge the diameter
D. Beaded cathode
E. Shaped end fitting into suitable mica slot
F. Lug formed to give mica location
G. Side embossings

Valve Impedance

To keep the envelope and getter as cool as possible the total dissipation in the valve must be kept small, and therefore the valve impedance has to be the minimum possible, as determined by peak inverse voltage requirements and/or mechanical tolerances. Fig. 4 shows an empirical curve relating minimum clearance to peak inverse voltage, and design adjustments have to be made until a satisfactory compromise is obtained.

Practice has shown that the impedance is also dependent upon the application. For A.C./D.C. sets where the H.T. voltage is limited, very low impedances are necessary controlled only by mechanical considerations. For A.C. set types the impedances and clearances are larger, while for high voltage types where large external series resistances are essential there is considerable latitude as the valve impedance can only be a small part of the total circuit resistance. Rectifiers performing the same function, but made by different manufacturers, have impedances varying by as much as $2\frac{1}{2}/1$.

Anode Dissipation

The temperature rise of the anode must be limited to a figure of about 400° C., and therefore it is necessary to set a limit on anode dissipation. The valve maker does not normally specify this as a rating because it is not easy for the user to measure and maximum D.C. output current is usually given instead. Nevertheless, the valve maker needs to know in detail the performance of the anode and usually carries out three interdependent checks:

1. *Actual Anode Wattage Measurement.*

While it is possible to take simultaneous readings of current and voltage across the valve and to integrate the power loss in each cycle, a more elegant method is to use a bolometer. Fig. 5 shows such an instrument in use. When the valve reaches steady running conditions the output of the thermopile is measured and then, without moving the valve or thermopile, the rectifier anode is supplied from a D.C. source, thus enabling the instrument to be calibrated directly in terms of wattage dissipation in the anode.

2. *Anode Temperature Measurement.*

Special valves are constructed, having a thermocouple of fine chromel-alumel wires welded to the centre of the anode and brought out via a special seal. Measurements of anode temperature are made for varying cathode watts and for a number of anode wattages, and thus the actual anode temperature for any desired operating condition is available, this data being plotted as in Fig. 6.

3. *Back Emission Measurement.*

In the course of processing and running a thermionic rectifier a certain amount of barium from the cathode is deposited on the anode surface, this contamination forming an emitting area should the anode temperature be sufficiently high. If the anode is operating at a temperature such that primary emission of electrons is taking place, then, during the negative half-cycle on the rectifier, electrons from the anode bombard the cathode and can produce premature failure. By testing the valve in a circuit as shown in Fig. 7 a curve of back emission current against output can be plotted. Such a curve is illustrated in Fig. 8 and the "knee" indicates the region of output current below which back emission is effectively zero and above which the anode temperature is such that back emission increases continuously with output current. This method does not entail making up special valves but requires considerable technical skill in assessing the merits of a particular valve as the curve is often gradual; allowances must be made for mica leakages and circuit capacities to earth, and the valve must be adequately stabilised by ageing.

Such a test as this contributes information on the amount of anode contamination present, and Fig. 9 shows photographs of anode surfaces giving bad and good back emissions.

Anode Design

It is customary to employ various forms of bright or coated nickel or iron for the anode material. The bright surfaced metal will satisfactorily radiate 0.25 watt/sq. cm., which figure is quadrupled if a black-surfaced material is used.

The heat in the anode must be distributed over the surface as evenly as possible, but the material thickness is limited to about 0.005 in. to permit thorough degassing on machine pumps working at normal speeds in mass production.

With particular anodes the heat concentration may be such that parts of the anode may be excessively hot at dissipations well below this rating and for this reason peculiar shapes of anode are used. As shown iin Fig. 9, fins are fitted or the anode is shaped so that the radiating surface is increased immediately around the part in which energy is being dissipated. Excessive temperature may result in gassing of the anode giving short life, but the most dangerous feature is that of primary anode emission or "back emission." The edges of the anodes are important from the point of view of field emission. It is possible with only a few thousand volts inverse to have a steep local gradient sufficient to cause field emission if the edges are ragged and it has therefore been found to be a marked advantage to flare the ends of high voltage rectifier anodes, even for voltages as low as 5 KV inverse.

Voltage Considerations in Design

Insulation

For low voltage types of rectifying valves, mica insulation is satisfactory. This material is standard for all radio receiving types where the maximum peak inverse voltage does not exceed 2 KV and it can be employed up to voltages of the order of 10 KV provided that the mica used is free from inter-layer metallic striations and care is taken that the surface is free from grease and other carbonaceous material.

Lead glass can be used safely with voltage gradients of 1,500 volts per millimetre. An example of the application of this is shown in Fig. 10, which valve has 15 KV peak inverse across 10 mm. of glass, and it will be seen that in this case the glass pillars are made as an integral part of the pinch structure. For more complicated forms of structure, glass is not mechanically suitable and ceramic is resorted to as an alternative. This material can withstand the same order of potential gradients, but is more subject to surface contamination because of its rougher surface.

Electron Bombardment

The voltage performance of insulators is very much impaired if they are subjected to electron bombardment. Trigger arcs are built up across the surface causing the release of gas and subsequent valve failure and it is good practice to design in such a manner that insulators are placed so that they cannot be bombarded, but where this is not possible it is usual to shield them by enclosing them in metal. Referring again to Fig. 10, early developmental samples used an unprotected mica bridge for supporting the filament springs, and although in this case the mica only had the filament voltage across it, serious trouble resulted from charges built up on it and the problem was only solved by the fitting of metal shields.

Bulb Charges

When high peak inverse voltages are involved bulb charges can be very serious. Electrons from the cathode which can take a direct path past the anode and impinge on the glass bulb can build up charges having potentials of the same order as the D.C. voltage. The getter patch is particularly susceptible to this charging effect and if large enough can flash over to the nearest electrode. To overcome this trouble it is necessary to prevent free electrons having a direct sight of the bulb and this involves restriction of the cathode length and the use of end shielding.

Bulb Location

To make valves suitable for normal transport it is desirable to support the anode in some manner from the bulb. Such locators may be of metal or of insulating material such as mica, and a representative collection of types is shown in Fig. 11.

Anode Leads

Attention has to be paid in high voltage types to the type of anode lead-out employed, particularly in valves of small physical size. The voltage gradient at the seal can overstress the glass causing small cracks and finally giving air leaks, this being particularly noticeable on

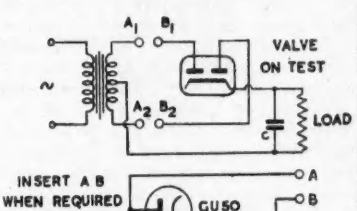


Fig. 7. A circuit diagram of a unit used for back-emission measurements

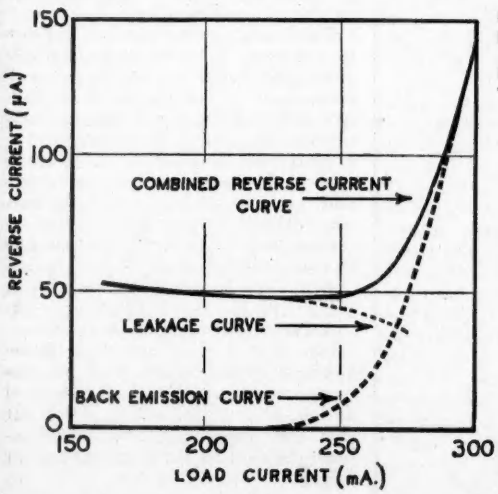
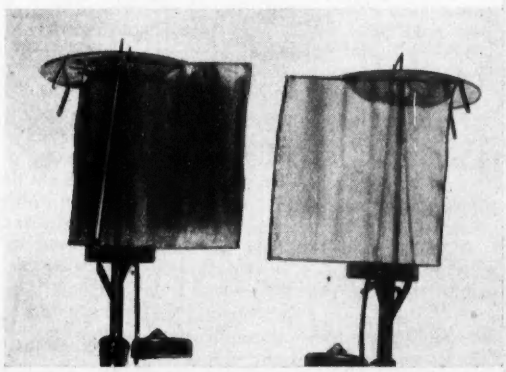


Fig. 8 (left). D.C. output current plotted against reverse anode current showing component leakage and back emission curves

Fig. 9 (right). The left-hand valve shows the inside surface of an anode heavily coated with deposits originating from the cathode coating. The right-hand valve shows the appearance desired after pumping



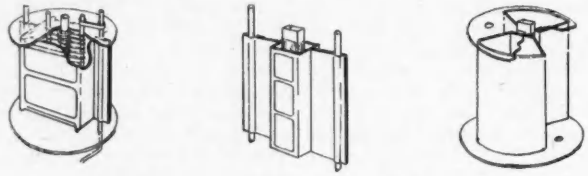


Fig. 9. Various types of electrode structures used to obtain a low anode impedance

Fig. 10 (centre). Various constructional features used to improve voltage performance

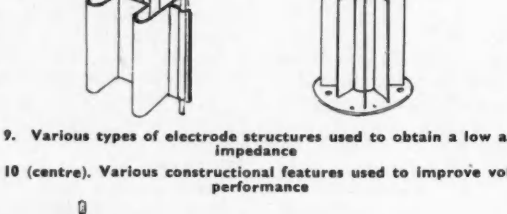
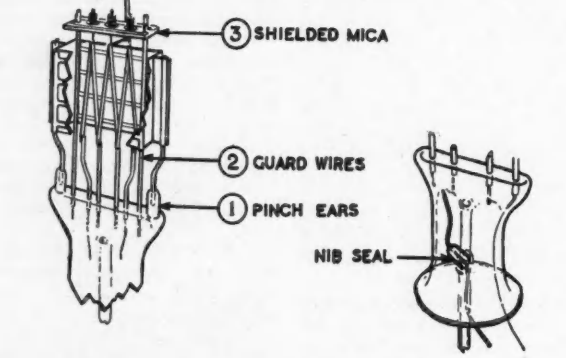


Fig. 11. Types of bulb locating devices

A. Wire "snubbers"
B. Rigid central supporting top lead
C. Stiffened locating micas
D. Metal springs
E. Flexible "wing" micas
F. Pips locating on the glass—the pips are of varying size to allow for bulb diameter tolerances



feather-edged metal/glass seals. Such stresses are reduced by fitting a cap over the seal such that a large area of glass is covered, or by "silvering" a part of the bulb.

Bulb Temperature Measurement

The reduction in the size of equipment and its use under tropical conditions makes it important that equipment designers as well as valve makers shall maintain close checks on achieved bulb temperature. The steady reduction in valve sizes has made valve designers very conscious of this matter as bulbs operating at temperatures exceeding 250° C. are liable to electrolyse, giving poor insulation and liberation of gas. Excessive getter temperature causes the getter to migrate and ruins its ability to absorb gas occluded during life.

An empirical method of temperature measurement employed with some success is the use of Thermetric paints. By painting the bulb with dots of various paints sensitive to a range of temperatures a permanent record of the temperature distribution of the whole valve can be obtained even though the valve is enclosed and is in an inaccessible part of an equipment.

The most accurate method is the use of a surface thermocouple of iron and constantan, mounted on the surface of the bulb.

Future Developments

These appear to be mainly in two directions, one being the use of oxide-coated cathodes at higher values of operating voltage and the other a miniaturisation policy of getting equivalent outputs from valves of smaller physical size.

Oxide-coated cathodes are inferior to tungsten filament types on the score of flashover tendencies and robustness to overloads, but have size, efficiency and economic advantages. Examples of recent experimental work are half-wave rectifiers with peak inverse voltages of 7.1 KV and current ratings of 250 mA, 500 mA and 1 amp respectively.

Size reduction is best shown in the following types:

U33 18 KV PIV, 3½ in. long.
U29 30 KV PIV, 5½ in. long.

A further interesting development is the E1524 rated at 500 0-500 V, 250 mA output which is 2½ in. long compared to the U52 with the same rating, but which is 5 in. long. In this case the anode impedance has been reduced by the expedient of gas filling.

(To be continued.)

The Luminescence of Simple Oxide Phosphors

By R. B. HEAD, M.Sc.(Eng.)*

THE simple oxide phosphors constitute a range of materials which have been rather poorly investigated, probably because, with few exceptions, they are inefficient. They are, however, of considerable academic interest because they represent about the simplest class of luminescent materials, and being, in general, very insensitive to heat-treatment and the addition of fluxes, provide data from which conclusions may be drawn with more confidence than from more complex compounds.

The present investigation was made under considerable difficulties and provides qualitative rather than quantitative data. In spite of this, it is hoped that the writer's observations will shed some light on the subject from a broader angle.

Sir William Crookes was undoubtedly one of the first workers to examine the simple oxides under cathode-ray excitation, but the observations made in many cases suggest that the source of excitation was an ion rather than an electron beam, owing to the relatively poor vacua then available. In spite of this, Crookes examined some pure unactivated oxides, such as beryllia, which he describes as giving a "beautiful blue phosphorescence." This material, however, belongs to the class of "impossibly dull" materials. He also synthesised a number of chemically unstable phosphors, the alkaline earth oxides. The writer has repeated this work successfully, and has applied these materials to cathode-ray screens by means of a special technique.

A means of obtaining quantities of basic materials of sufficiently high purity for this experimental investigation had to be found so as to provide at least several pounds of each pure compound. In some cases the hydroxide was precipitated, when due precautions were taken to keep the carbonate content as low as possible. The purity reached in most cases (based on the iron content) was about 2×10^{-7} parts per part, and was in some cases a good deal better than this. A difficulty encountered with precipitated hydroxides was the complete removal of alkali nitrates, and none of the precipitates could be said to be spectroscopically pure, although very low in alkali metals. All the preparations were carried out on a small laboratory scale.

Table I shows some results obtained by heating small quantities of the pure oxides, and then exciting them by means of cathode-rays. It is seen that beryllia, magnesia, alumina, boron oxide and thoria give very dull dilute bluish fluorescence, and zirconia, a brighter bluish-white. No oxides possessing black-body colours were found to fluoresce in the visible range, although dark-coloured phosphors are known. Luminescence thus seems confined to the oxides of metals occurring generally in Groups II, III, and IV of the Periodic Table.

The most important of these is Group II. It was not found possible to activate beryllia with any elements except manganese and chromium, both of which gave extremely dull orange phosphors. Magnesium oxide was extremely disappointing, since the phosphors formed are very dull, and show a tendency to burn with a change of colour. Zinc oxide, prepared at low and high temperatures in oxidising atmospheres gives a yellow* fluorescence under cathode rays. Activation by manganese and cadmium was found to produce green fluorescence, but with larger quantities, yellow, and finally dull red fluorescence. Uranium and cerium gave screens in all quantities. Cerium was remarkable for the flame luminescence shown at high temperatures with as little as 5 parts per million, but a phosphor containing 1 part in 5,000 showed a somewhat longer afterglow than ZnO (Zn), with a comparable efficiency. Molybdenum was found to act as a killer, but encouraged burning.

The most efficient zinc-oxide phosphor obtained was a zinc-activated material produced by burning zinc vapour in an insufficient supply of oxygen, and firing this material at a dull red-heat in a slightly reducing atmosphere. Some samples of ZnO (Zn) prepared from precipitates hardly showed fluorescence under ultra-violet excitation, but were fairly efficient under cathode-rays. Certain forms of zinc-oxide show a very marked increase of efficiency under ultra-violet excitation when cooled to the temperature of liquid air, when the afterglow, instead of being extremely short, is visible for several seconds.

All forms of zinc oxide, including the yellow forms, were found to show ion and electron burn, and it appeared at an early stage of the investigation that oxides possessing low heats of formation would be very liable to show burning. For this reason, the bulk of the investigation was confined to calcium, strontium, and barium oxides, since these possess high heats of formation. All these materials are unstable in moist air. In some cases exposure for only two or three minutes greatly reduces the efficiency under cathode rays. In the preparation of phosphors from these materials, no fluxes of any sort were used, so as not to confuse the properties of the materials.

After a number of preliminary experiments, it soon became clear that:

(a) Calcium oxide is a prolific source of phosphors, and every element, almost without exception, produces a characteristic fluorescence under cathode rays, even iron, nickel and cobalt.

(b) The colour of fluorescence of calcium oxide phosphors is very insensitive to the concentration of the activator.

(c) The colour of fluorescence depends entirely on the chemical state of the activator, *i.e.*, the activating oxide may be reduced to a lower state by hydrogen-firing the phosphor.

(d) There is some connexion between the colour of fluorescence and

* Cinema-Television, Ltd.

* J. A. Radley and J. Grant, (P. 201, *Fluorescent Analysis in Ultra-violet Light*).

the position of the activator in the Periodic Classification, but the efficiency of calcium oxide is very low compared to other oxides.

(e) Strontium oxide forms few phosphors.

(f) Barium oxide forms no phosphors fluorescing in the visible range, unless a proportion of beryllia is present.

Calcium Oxide

The results obtained by activating calcium-oxide by traces of every available element are shown in Table II. It is found in many cases that when the activator is reduced to the elemental state, or at least a state of lower valency by means of hydrogen-firing, the luminescent band is completely different to that obtained under oxidising conditions. Where possible, the phosphors are tabulated so as to show the colour of fluorescence under both oxidising and reducing conditions. H. Jackson* stated that "if calcium oxide which luminesces bright orange is heated in an oxyhydrogen flame it subsequently gives a blue phosphorescence." It is found that this occurs with a number of *CaO* phosphors, and both blue and yellow forms are often present at once. This appears to be due to the fact that both oxidising and reducing conditions are present simultaneously. Further evidence is added by the fact that *CaO* (*Ce*) shows only yellow fluorescence when so prepared, and reference to Table II shows that both oxidising and reducing conditions give yellow fluorescence (band spectrum). It is, however, surprising that cerium present in either the tervalent or tetravalent states gives the same spectral distribution.

A rather peculiar effect is shown by the phosphor *CaO* (*Y*). This material, unlike *CaO* (*Sc*), or *CaO* (*La*), gives twelve or thirteen separate luminescent bands, including a fluted orange band. The result of heating the phosphor (whose cathodoluminescence appears whitish) in an oxyhydrogen blow pipe is to produce lumps whose luminescence varies in colour from red to blue. Spectroscopic examination of each lump, shows that all the bands are present in each case, but that some have been apparently accentuated with regard to others. The phosphors *CaO* (*Sc*) and *CaO* (*La*) show marked visual differences when prepared under both oxidising and reducing conditions, but here again, the spectroscope shows only an accentuation of certain bands. (Where the activating oxide is easily reduced, as with *Pb*, *Tl*, *Bi*, etc., a totally different band makes its appearance, to correspond with a state of lower valency, or even an elemental state).

Calcium oxide activated with rare-earths is of interest, since, although the phosphors are inefficient, they are very resistant to burning. The rare-earth oxides are not reduced by hydrogen and possess high heats of formation, and since calcium oxide itself is irreducible, it could be predicted that such phosphors would be very robust. It has long been known that the rare-earths form coloured compounds with one another, the commonest case probably existing as the contamination of ceric oxide with praseodymium. The darkening of the body colour of *CaO* (*Ce*) in reducing conditions could be understood, as the colour of Ce_2O_3 is grey-green, and that of CeO_2, a light lemon-yellow. The writer has found that in the case of other rare-earth activators such as scandium, lanthanum, dysprosium, there is always a darkening of body-colour, although these rare earth-oxides are irreducible, and only one oxide of each metal is known. A comparison of pure samples of calcium oxide fired under both conditions showed no such darkening, and, since the rare-earths used were approaching spectroscopic purity, it appears that calcium oxide may perhaps be induced to form traces of coloured compounds with rare-earths in the presence of reducing conditions. References to this phenomenon are given in Mellor, Vol. 5, where ceria-thoria mixtures are cited as showing a darkening when heated and cooled in a reducing atmosphere. One worker claimed to have obtained cerium hydride, by heating ceric oxide and magnesia in hydrogen. This hydride was said to possess a "blue-black" colour and may have been $2CeO_2Ce_2O_3$ cerous cerate.

In the case of cerium (which occupies a special position in the rare-earths series), Kröger and Bakker* have shown that with a number of base materials, the cerium only promotes luminescence when present in the trivalent state. The phosphors, $SiO_2(Ce)$''' and $SrO(Ce)$''' certainly require preparation in a reducing atmosphere in order to induce luminescence, although very faint luminescence is observed when prepared under oxidising conditions. $CaO(Ce)$ would appear to be an exception, and the writer has found other exceptions where the basic material is more complex than a single oxide.

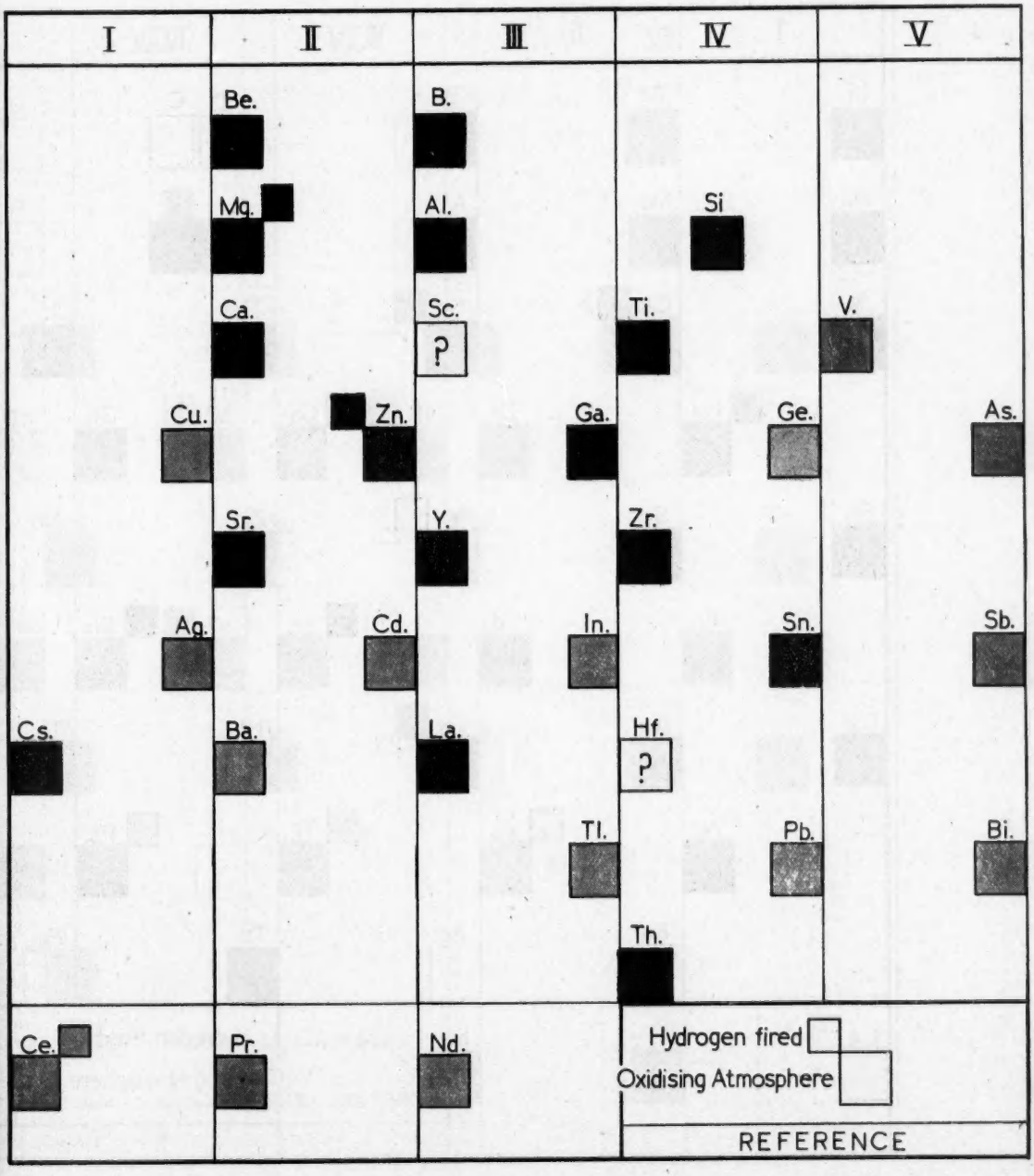
It has been found possible to prepare materials in which the activator exists in both states simultaneously. The material $SrO(Bi)$ (*oxidising*) possesses a blue fluorescence. $SrO(Bi)$ (reducing) possesses a yellow-green fluorescence. On hydrogen-firing the blue phosphor, the yellow-green band gradually makes its appearance, and if the firing is stopped at the correct point a phosphor possessing a "white" fluorescence is obtained as both blue and yellow bands are present simultaneously. If the material initially contains the normal amount of bismuth, the body-colour will change to grey after hydrogen-firing and bismuth metal will be lost by volatilisation. In most cases where the activator is reduced to the elemental state, it appears less soluble in the basic material than when the activator is present, presumably as a solid solution of one oxide in another. The particularly inefficient material, $CaO(Pt)$ exhibits yellow fluorescence under oxidising conditions, and this may be due to the fact that the platinum is present in the metallic state.

One of the most interesting calcium phosphors is $CaO(I)$. In the state *CaO* (CaI_2), the fluorescent colour is blue, but if prepared by admitting a trace of iodine vapour to calcium oxide under reducing conditions, a much brighter material is produced, giving an egg-yellow fluorescence. This material is very temperature-sensitive, and very difficult to prepare properly. On heavily bombarding the yellow form with cathode-rays, it "burns back" to the blue form. Presumably the iodine, existing in a very reactive and possibly elemental state links up with the basic material under the opportunity afforded by the disturbance due to bombardment. Both blue materials possess identical or almost identical spectral distributions. In this case,

* (Mellor) "A Comprensive Treatise on Inorganic and Theoretical Chemistry" Vol. III. p. 662.

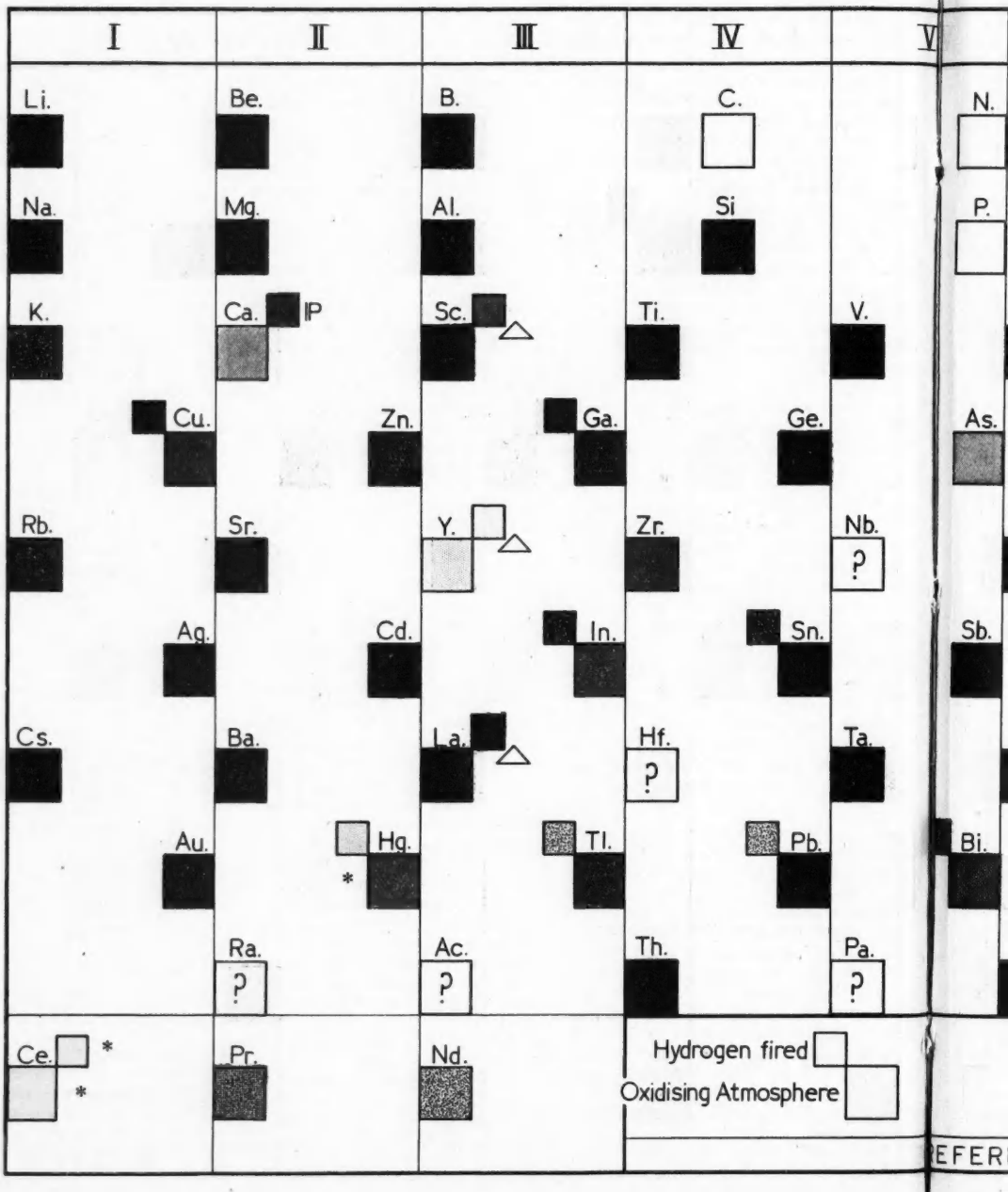
* "The Luminescence of Cerium Compounds" (Laboratoria—N. V. Philips Gloielampenfabricken, Holland).

Table 1. Unactivated Oxides *(Cathode-ray Excitation)*



Owing to the limitations of colour printing, this diagram should only be taken as indicative of the colours produced. The degree of brightness is shown by the depth of black shading. Squares cross-hatched in black indicate no luminescence.

Table 2. Calcium Oxide Phosphors



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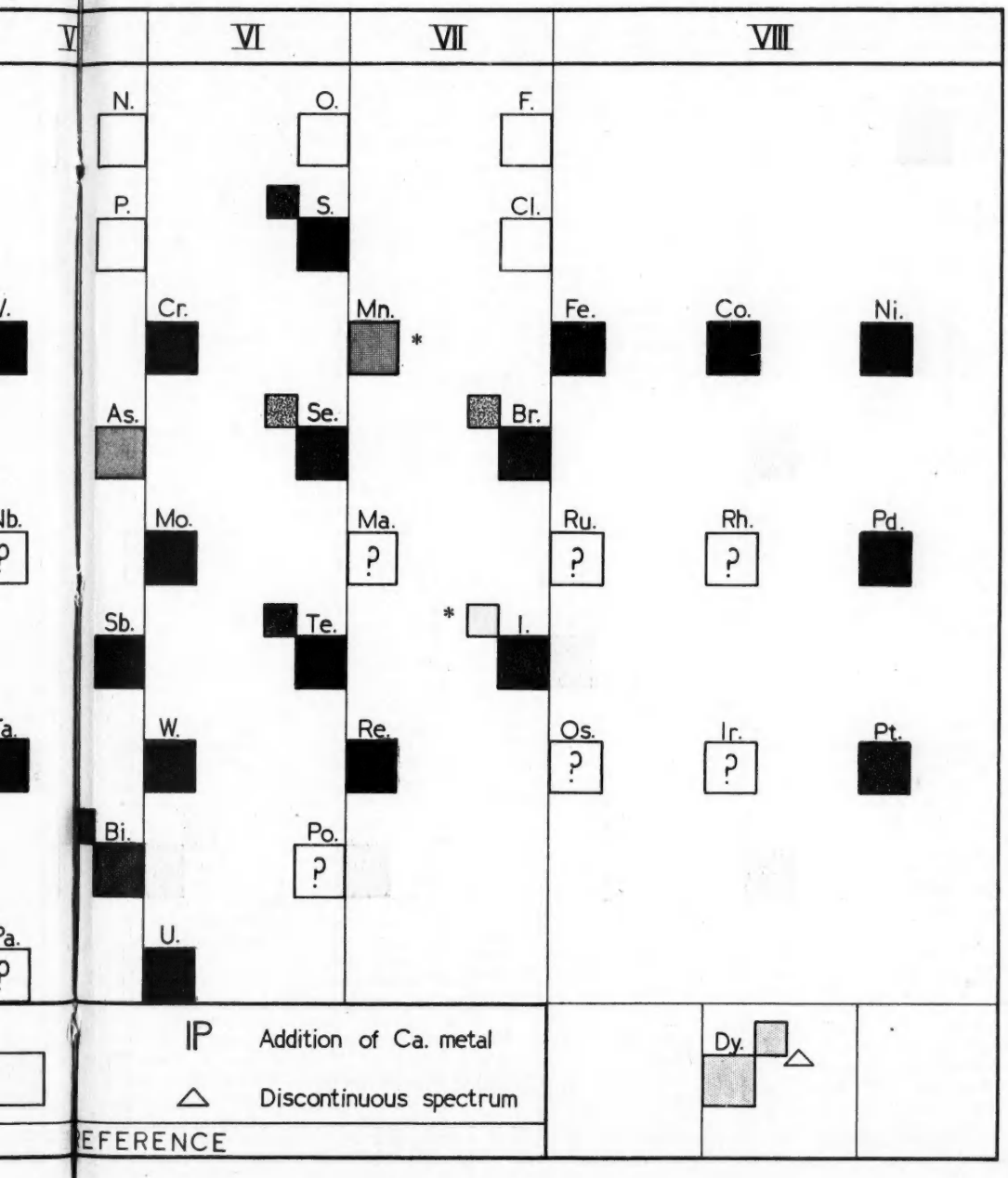
The degree of brightness is shown by the depth of black sha... *Indicates ...

Phosphors *(Cathode-ray Excitation)*



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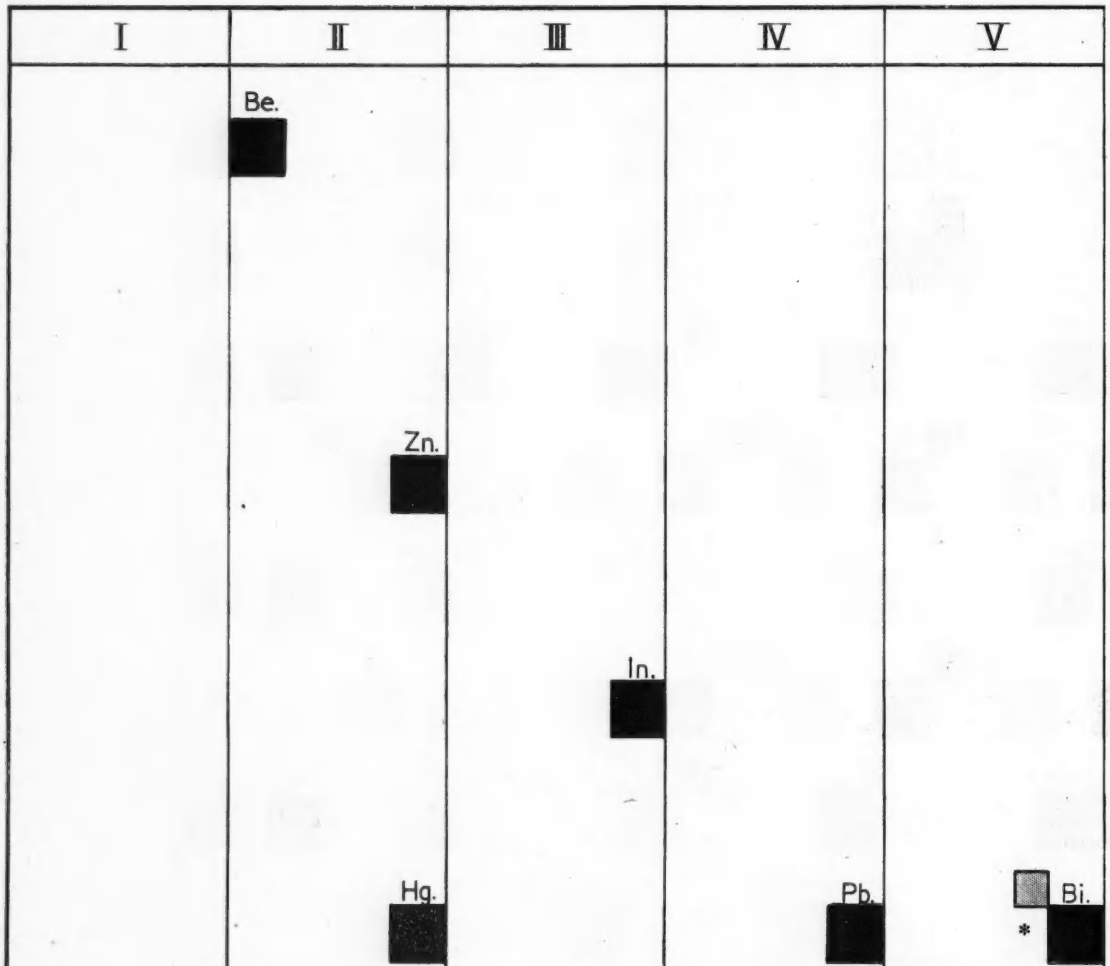
s diagram d only be taken as indicative of the colours produced.

black shaf *Indicates very bright colour. Y and Dy are nearly white

Table 3. Strontium Oxide *(Cathode-ray Excitation)*



Owing to the limitations of colour printing, this diagram should only be taken as indicative of the colours produced.

The degree of brightness is shown by the depth of black shading. Squares cross-hatched in black indicate no luminescence. *Indicates very bright colour

a form of " burning " does not actually destroy the luminescence, but cases can be cited in which both the " oxidised " and " reduced " forms of a materal can be burnt to a non-luminous substance. One such case is the material *CaO(Cu)*, which exhibits green fluorescence in the oxidised form, and very dull blue fluorescence in the reduced form. Both these forms burn to non-luminous materials, the body-colour of each becoming grey. A still more peculiar phosphor was prepared by the addition of a trace of bismuth to *CaO(Cu)*. On first bombarding with cathode rays, the dull violet of *CaO(Bi)* was observed, but in a few minutes this was superseded by the much brighter green of *CaO(Cu)*. After a short while, the material burnt to a non-luminous state.

Stability

It was noticed that the inclusion of activators such as zinc, copper, antimony, etc., in calcium oxide caused speedy and violent ion-burning. Since the oxides of such metals possess low heats of formation it appeared that robust phosphors could probably be prepared by limiting the activating oxides to those possessing high heats of formation, such as the rare-earths, phosphors such as *CaO* (*Ce, Sc, Y*, etc.) were found to possess remarkable stability, and under the existing experimental conditions no burning was observed even when gas was present during bombardment. It is difficult to say whether it is possible to synthesise a material showing entire absence of electron-burn, as this type of burn can be produced by so many factors. As will be shown later, materials have been prepared which " burn brighter " instead of duller. There is little doubt that ion-burning does not cause chemical reduction. In the case of zinc oxide, *ZnO(Zn)*, an actual darkening of body-colour is produced by bombardment with negative ions. Lumps of $Al_2O_3(Cr)$, which have been fused at a very high temperature appear as if chromium-plated after heavy ion-bombardment and this is almost certainly due to chromium metal, since pure Al_2O_3 and natural sapphires from different sources do not show this effect. The phosphor $SiO_2(Ce)$ appears to be stimulated by ions, without showing ion-burn at all, so that the positive ions of a cathode-ray tube produce a central luminous ion-spot on the screen. This material shows electron-burn of two types, burning brighter than the unbombarded screen at high current densities, and duller at low current densities.

A conclusion reached so far, is that in order for a material to possess high stability, the basic oxide and the activating oxide must both possess high heats of formation. This conclusion is unlikely to be general since the phosphor *SrO(Bi)* happens to be rather robust, although bismuth oxide possesses a low heat of formation (*see* Table III). Zinc ortho-silicate in addition to zinc oxide, is easily reduced by hydrogen-firing. The stability of the former compound contrasted with the instability of the latter compound suggest that the ease with which reduction takes place under cathode-rays depends very much on the type of chemical bond existing between the zinc and the acid radicle.

Connexions between Fluorescent Colour and the Periodic Table

Reference to Table II shows that for calcium oxide, there appear to be some connexions between the colour of cathodoluminescence, and the position of the activator in the Periodic Table, for some sub-groups.

In the cases of *CaO* activated with the following elements, *S, Se, Br, Sn, Te, I, Hg, In, Tl, Pb, Bi*, and *SrO* activated with *Bi*, a completely new band of luminescence has been observed on firing the phosphors in hydrogen.

Strontium Oxide

Where this material is prepared from the monohydrate which melts at about 400° C. difficulty is sometimes experienced owing to the formation of a hard cake of oxide. It is found that if the hydroxide is heated in a tall crucible from the top only, the last traces of water are expelled in such a way as to produce a " foam " of bubbles.

On calcining this foam at temperatures as high as 1,450° C., it falls easily to a crystalline powder on stirring with a rod of alumina. This process forms the subject matter of a pending Patent Application in the joint names of Cinema-Television, Ltd., and the author. This material is very strongly alkaline, and hygroscopic, so that exposure to air must be limited to three or four minutes. During the preparation, it is advisable to use prewarmed vessels, and preferably to carry out sieving operations in a special box into which absolutely dry gas is passed. The operators must wear rubber gloves, and masks, since inhalation of the powder causes violent sneezing and nose-bleeding.

It is interesting to note that at least two Strontium oxide phosphors possess long afterglows, although these are very inefficient. They are *SrO(Hg)*, and *SrO(In)*. There appears to be some very strong chemical bond between the mercury activator and *SrO* or *CaO*, since extremely little is lost on calcining at high temperatures.

Strontium oxide can be activated by beryllium to give an inefficient blue phosphor. The quantity of beryllia is critical, but both *SrO(Be)* and *SrO(Bi)*, while possessing short afterglows at room temperature, exhibit long blue afterglows at temperatures in excess of 200° C. under ultra-violet excitation, and no satisfactory explanation of this was forthcoming at the time of writing. Strontium oxide, generally speaking, is much more sensitive to impurities than calcium oxide, and electron and ion burn are greatly encouraged by the presence of carbonate before firing. This can be demonstrated effectively if *SrO(Bi) is* prepared by passing oxygen over heated $SrCO_3$ to which the activator has been added. The carbonate is never completely converted to oxide, and comparison of this material with phosphors made from hydroxide containing some carbonate, and the nitrate, show the importance of minimising the carbonate content.

Efforts to chemically stabilise *SrO(Bi)* by additions such as *MgO, CaO*, etc., have not shown much success. The addition of *MgO* caused bad burning, and an increase of the afterglow, but the *CaO* addition (in equimolecular proportion) showed an increase of afterglow, but gave a material which " burnt brighter " under heavy bombardment. It must be noted that both *CaO* and *SrO* are activated by bismuth. Addition of silica to strontium oxide reduces the efficiency by an enormous amount.

Double Oxides

It is seen from Table II, that all elements in Group II of the Periodic Table induce blue fluorescence when used to activate *CaO*. The result of heating any two oxides from Group

II, without an activator also produces materials possessing blue fluorescence, although all of these materials are extremely dull.

The double oxide, *CaO.ZnO* possesses a blue fluorescence under cathode rays, and a dull yellow fluorescence under ultra violet excitation, which is enhanced at the temperature of liquid air. This material shows burning, and appears to possess a somewhat longer afterglow than its components. The cause of luminescence might be due to a form of double lattice distortion, since no activator is present. This appears to be a similar case to the tungstates, $CaO.WO_3$, $CdO.WO_3$, $MgO.WO_3$, all of which give blue or violet fluorescence without activators. In these cases the afterglows are considerably longer than many *CaO* phosphors.

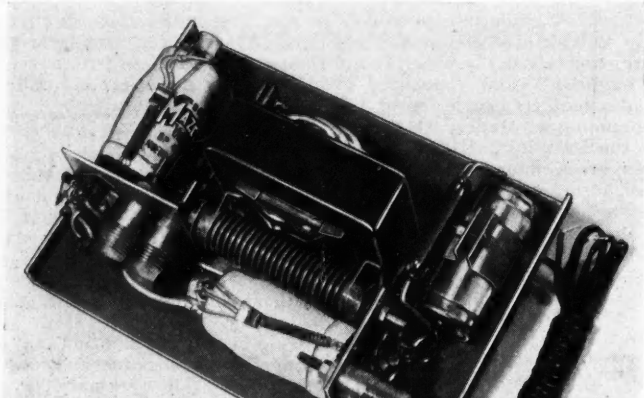
Double oxides with activators are usually still more efficient and often possess still longer afterglows, examples being calcium silicate (*Mn*), germanates, phosphates, etc. There appear to be very few activators for most of the more complex compounds, and this suggests that two or more conditions have to be fulfilled simultaneously by the activator.

Afterglow

It is of interest that the shortest afterglow appears to be possessed by *CaO*(*Ce*), for which the writer obtains a rough figure of 0.2×10^{-6} seconds.

Unactivated zirconia exhibits an afterglow with a long "tail" but the shape of the curve follows a simple law. *SrO*(*Bi*), a much more efficient material, possesses a more complex form of afterglow, represented by two time-constants. Willemite, a still more efficient material, possesses a much longer afterglow, and this appears also to follow complex laws. There has been recent evidence to show that the addition of a fifth oxide to zinc beryllium silicate, still further increases the afterglow. The conclusion to be drawn from here seems to be that afterglow and efficiency increase in proportion, between certain limits, and that materials possessing short afterglows must be (a) inherently inefficient, and (b) very simple in constitution.

The writer is indebted to Cinema-Television, Ltd., for permission to publish this work.



A Television Pre-Amplifier

THE type T.A.B. television pre-amplifier shown in the photograph is designed for use with television receivers where an increase in sensitivity is required. It will considerably extend the range from Alexandra Palace at which a receiver may be satisfactorily operated, and in the "fringe" areas where the signal is beginning to fall off an improvement in the contrast and clarity of the picture will be obtained by its use.

Both sound and vision signals are amplified equally by the pre-amplifier, which is connected into the aerial feeder between the aerial and receiver. The unit is self-contained with its own power pack and the only connexions required are the incoming and outgoing feeders and the mains cable, which should be connected into the switched mains circuit of the receiver.

Two high-gain H.F. pentodes are used to provide the necessary gain at the very wide bandwidth used. A gain control is provided in order to be able to adjust the signal input to the receiver to the optimum level; the maximum gain is approximately 30 db. An impedance of approximately 80 ohms is used for input and output, co-axial sockets being provided for the terminations. The response of the amplifier is substantially flat between 41-48 megacycles. The amplifier is pre-set permeability tuned and utilises four tuned circuits, high "Q" coils wound on distrene formers.

The unit is contained in a louvred steel case $7\frac{1}{4}$ in. long by $5\frac{1}{4}$ in. wide by $2\frac{5}{8}$ in. deep and four fixing lugs are provided for attachment purposes. The front panel carries the input and output co-axial sockets together with the gain control, the mains lead also being brought through this panel.

Padder Unit

In order to provide for the running of more than one television receiver from a common aerial system without mutual interaction, an isolating padder unit has also been designed. This unit permits of up to three receivers being run together and attaches to and matches the pre-amplifier. A reduction of overall gain between the input and the three outputs occurs owing to the attenuation of the isolating network. This reduction is approximately 16 db, leaving an overall gain between input and each output of approximately 14 db.

The makers of the pre-amplifier and padder unit are Messrs. Clive Courtenay & Co., Ltd., of Horsham Road, Dorking, from whom further particulars can be obtained.

H.F. Pentodes in Electrometer Circuits

By K. D. E. CRAWFORD, Grad.I.E.E.*

A NUMBER of circuits of the electrometer type have appeared in the technical press in which a normal type of receiving valve has been used instead of the special electrometer valve usually employed. Very little information is, however, available to indicate either how far this substitution may be taken or what are the best operating conditions for the valves. The following investigation was therefore undertaken to ascertain the suitability of certain British valves when employed in circuits of this type. As the work was proceeding, an article[6] describing similar work on American valves appeared in the *Review of Scientific Instruments.*

Grid Current

The paramount requirement for an electrometer valve is that it shall present a high impedance to the source, and in fulfilling this need various difficulties are met. It is found with all valves that when the grid is made sufficiently negative to prevent electrons actually reaching it, there exists a small current in the opposite direction. This negative grid current is normally too small to be of any importance with conventional circuits, since it is of the order of 10^{-10}A. When, however, grid leaks of 100 megohms and above are employed, as is quite common in electrometer circuits, effects due to this current become noticeable.

The causes of this grid current have been stated by Metcalf and Thompson[1] and their findings are given below:

1. Leakage over glass or insulation.
2. Ions formed by gas present in the valve.
3. Thermionic grid emission due to heating of the grid by the filament.
4. Ions emitted by the filament.
5. Photo-electrons emitted by the control grid under action of light from the filament.
6. Photo-electrons emitted by the control grid under action of soft X-rays, produced by the normal anode current.

* Mullard Radio Valve Co., Ltd.

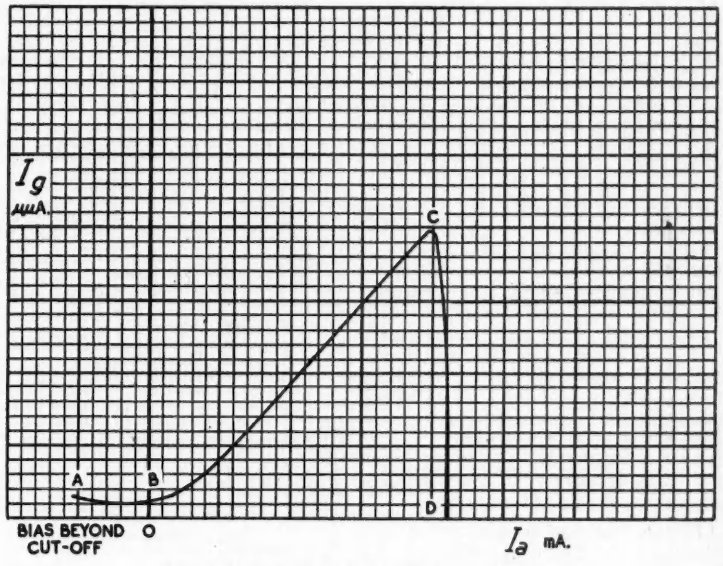


Fig. 1. I_g/I_a characteristic at constant anode voltage

In the following measurements no attempt was made to isolate completely each of the above effects from the others. The only separation made was to note the effects of independently varying the electrode potentials and from the results of these experiments it appears that the predominating causes of grid current are due to effects 1, 2, and 3.

The leakage current can take place over both internal and external paths and in order to keep the external resistance as high as possible it is desirable to use a valve with top cap grid connexion. In practice it was found that the external leakage current was always considerably less than that through internal paths, provided that the bulb was kept reasonably clean and dry.

The ionisation current will depend in the first place on the degree of evacuation of the valve and secondly on the density and velocity of the electron stream, and in practice the total grid current in the region where ionisation current predominates is found to rise very nearly in proportion to the anode current and to the square of the anode voltage.

A reduction in the heater voltage was found to decrease the grid current with practically all the valves tested, and this is presumed to be due mostly to reduced grid emission, although other effects may also be present.

I_g/I_a Characteristics

The complete grid current/anode current characteristic at a constant anode voltage is of the form as shown in Fig. 1.

In the region A-B of this curve the anode current is cut off by the high bias voltage and the ionisation current is therefore zero. The grid current is then mostly due to leakage and grid emission. The slight rise shown at A is due to increased leakage through the grid cathode path as the bias voltage is raised.

As the bias is reduced the anode current increases and with it the ionisation current, as is shown by the rise in current from B to C. This portion of the characteristic becomes sensibly linear as it approaches the point C, when at this latter point positive grid cur-

rent commences to flow and to cancel the negative current. The total current therefore decreases until it passes through zero at point D where the two currents are exactly equal and opposite.

The effects of the slope of the grid current curve have already been pointed out by Morton,[2] who showed how the input impedance and effective mutual conductance were dependent upon this characteristic.

Consideration of Fig. 1 will show that over a small portion between A and B the input impedance is infinite decreasing to a positive resistance towards A. From B to C the resistance becomes negative and decreases in value until near point C itself it rapidly increases again and reaches infinity at C. It then becomes positive again and continues to decrease as point D is approached.

The valve is normally arranged to work somewhere in the region between B and C, *i.e.*, in the negative resistance region, and this means that the maximum resistance which can be put in series with the grid and any source of voltage is limited by considerations of stability and accuracy of calibration.

Limiting Value of Grid Leak

The maximum permissible value of grid leak can be found from the I_g/I_a characteristics in the following manner:

Assuming that the valve is working at a point where both the I_g/I_a and I_a/V_g characteristics are linear as shown in Fig. 2, then:

$$I_a = -(V_o - V_g)g_m \quad \ldots\ldots\ldots\ldots \quad (1)$$

$$I_g = -(I_aK - I_{go}) \quad \ldots\ldots\ldots\ldots \quad (2)$$

where $\delta I_a/\delta V_g = g_m$ and $\delta I_g/\delta I_a = K$

If now a grid leak R_g is inserted in series with a bias voltage E_g the voltage appearing on the grid will be the sum of the bias voltage and the voltage developed across the grid leak by grid current, *i.e.*:

$V_g = E_g - I_gR_g$ where I_g is negative. Combining this with Equations (1) and (2) gives:

$$I_a = -(V_o + R_gI_{go} - E_g)g_m \frac{1}{1 - g_mKR_g} \quad \ldots\ldots\ldots\ldots \quad (3)$$

From this it can be seen that as R_g is increased, I_a also increases until at the point where $g_mKR_g = 1$ the expression becomes infinity. In practice, of course, the I_g/I_a characteristic is not linear and, as I_a increases, K first increases and then decreases, as point C is approached, (Fig. 1) until it reaches zero at C.

If, therefore, the valve is operating at a point near B with a grid leak of value $R_g = g_mK$, where g_m and K are the slopes at the operating point, any small fluctuation will cause the operating point to move rapidly up the I_g/I_a characteristic until it reaches a point near C where $g_mKR_g = 1$. The maximum value of R_g with which the grid will maintain control of I_a over the whole of the curve is given by $R_g = 1/g_mK_{max}$. where K_{max}. is the maximum slope of the I_g/I_a characteristic between B and C. In practice it is necessary to employ a grid leak of much lower value than this, in order to ensure that stability will be maintained.

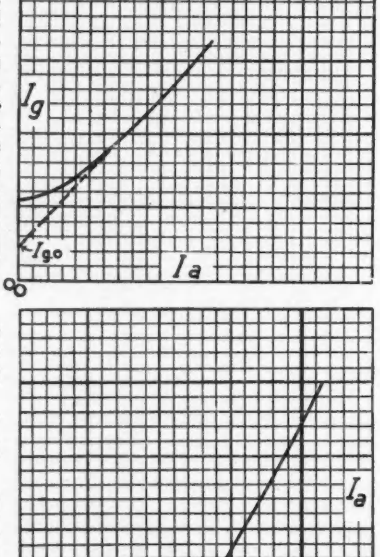


Fig. 2. (Top) I_a/I_g characteristic (Bottom) I_a/V_g characteristic

Change of Calibration with Source Impedance

In cases where the source impedance is very high it is of importance to know what variation in calibration of an instrument will occur when different impedances are used.

From Equations (1) and (3) it can be seen that the effect of varying the grid voltage through a high impedance R_g is to shift the origin of the I_a/V_g characteristic from V_o to $V_o + R_gI_{go}$, and to increase the slope in the ratio $\frac{1}{1 - g_mKR_g}$ (*see* Fig. 3), the latter becoming infinite when $g_mKR_g = 1$.

Assuming that R_gI_{go} is so small that it can be neglected or that it is cancelled by means of a zero setting device, the percentage change in I_a for series impedance of zero and R_g in the grid circuit is:

$$\delta I_a = \frac{g_mKR_g \times 100}{1 - g_mKR_g} \quad \ldots\ldots\ldots \quad (4)$$

Thus, if the error is not to exceed 1 per cent., then g_mKR_g must not be greater than 0.01.

Results of Measurements

Fig. 4 shows the results of some measurements of grid current made on an EF37 valve connected as a triode, $g3$ connected to cathode, anode and $g2$ strapped.

Inspection of these curves shows that at high anode currents, where the ionisation current predominates, the grid current I_g closely follows the expression:

$$I_g = \alpha I_gV_a^2$$

where α is a constant for the valve.

The grid currents obtained for very low values of I_a do not appear to bear any simple relationship to the anode voltage and were, in fact, found to be rather erratic in practice.

Measurements of the maximum value of grid leak with which this valve would remain stable showed close agreement with the theoretical values calculated from Fig. 4, although the exact point at which stability is lost is difficult to determine accurately. The results are shown in Table 1:

TABLE 1

Va = ...	50	100	150	200	250 Volts
Rg max (calculated) ...	60,000	5,000	1,300	800	630 Megohms
Rg max. (measured)—					
Stable	—	5,040	1,120	560	200 Megohms
Unstable	—	5,600	1,680	1,120	560 Megohms

The change in effective slope with this valve when operating at V_a = 150 with a grid leak of 560 megohms is about 1.5 times, while the shift in the origin due to R_gI_{go} is negligible.

The valve with which the above figures were obtained was selected

from several of the same type among which the grid current characteristics were found to vary widely. It can, however, be readily seen from these curves that the best operating conditions are obtained when the anode voltage and current are kept as low as possible. A further improvement at low anode currents not shown by Fig. 4 is obtained when the heater voltage is decreased to about 5 volts. This is most probably due to a decrease in grid emission. With this heater voltage and about 40 volts applied to the anode, the anode current obtained was equivalent to that of the Philips 4060 electrometer triode, while the maximum grid current under these conditions was $4\times10^{-12}A$ as compared with $1.6\times10^{-15}A$ for the latter valve, a ratio of 2,500 times.

Two dozen EF36 valves were tested under the above conditions. Of these, 15 per cent. had $I_{g\max.}$ less than $10^{-11}A$, 60 per cent. less than $2\times10^{-11}A$, and 90 per cent. with less than $5\times10^{-11}A$.

Apart from the magnitude of the grid current it is also of importance to know what degree of stability is to be expected. Tests on this indicated that most valves required a period of from half to several hours after switching on to allow the ionisation current to settle down to a steady value which might be anything from 20 to 50 per cent. less than the initial current. After this final current has been reached it remains steady to within 10 per cent. with a good valve, but in some cases erratic changes of a semi-permanent or permanent nature were observed and found to be due to alterations in the leakage resistances.

Special Circuits

Some considerable improvement in the limits to the operating conditions can be obtained by the use of one or two special circuit arrangements.

One method by means of which a slight improvement can be obtained is to use the valve as a pentode with the anode voltage some 30 volts below that of the screen. The grid current is then about 20 per cent. lower than with the triode connexion or when $V_a=V_{g2}$. Raising the anode voltage above that of the screen causes a rapid increase of I_g.

It has been pointed out elsewhere[2] that the use of a cathode follower circuit permits the use of much higher values of grid leak than is ordinarily possible.

It was shown previously that the maximum leak with which stability could be maintained was equal to $1/g_mK_{max.}$ where $K_{max.}$ is the maximum slope of the I_k/I_a curve and g_m is the slope of the I_a/V_g curve at that point.

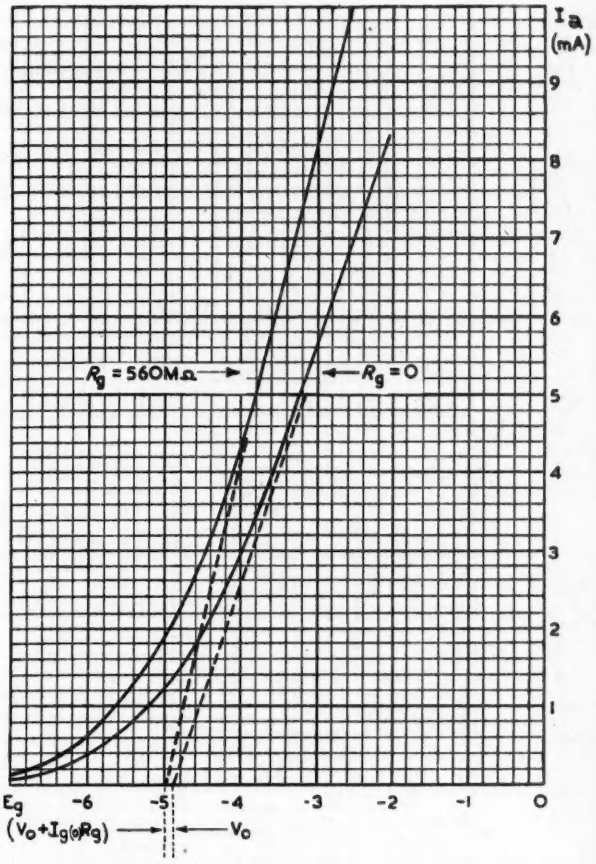


Fig. 3. Change of Ia/Eg characteristic with Source Impedance

With the cathode follower, however, the effective slope becomes:

$$g_{m(eff)} = g_m \frac{1}{1 + g_mR_k}$$

Where R_k is the load resistance in the cathode circuit.

Consequently the maximum value of grid leak now becomes:

$$R_{g\,max.} = \frac{\frac{1}{g_m} + R_k}{K_{max.}}$$

When R_k is made large the effective slope becomes independent of the slope of the valve and $R_{g\,max.} = R_k/K_{max.}$ Thus, by using a high value of cathode load the grid leak can be increased very considerably without loss of stability.

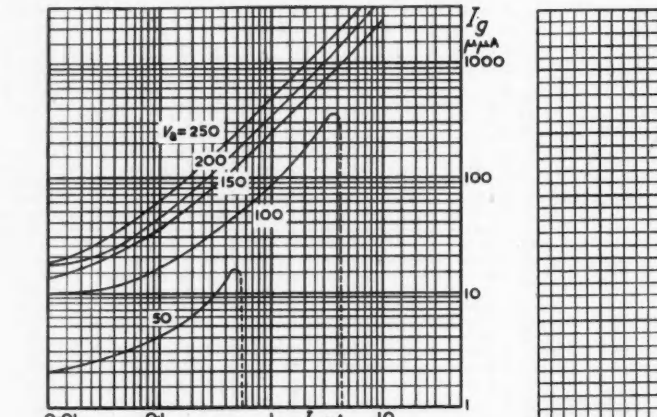
As an example, take the extreme case given in Table 1 for which, with an anode voltage of 250, g_m = 4 mA/V, and K = 400 $\mu\mu$A/mA, it was found that instability occurred when the grid leak was raised above 200 Megohms. If now a cathode follower is used with a cathode resistance of only 2,000 ohms, the maximum grid leak will be:

$$R_{g\,max.} = \frac{250 + 2{,}000}{4\times10^{-7}} = 5{,}600 \text{ megohms}$$

a value which was confirmed by experiment.

The percentage change in effective slope for different source impedances when using the cathode follower can be found by substituting $g_{m(eff)}$ for g_m in expression (4) and an example of the effect is shown in Fig. 5. Here the change in slope was calculated to be 8 per cent., which agrees very well with the curves.

By using cathode loads of the order of 1 megohm it is possible to keep the circuit stable with grid leaks of several million megohms and to make the variation of calibra-



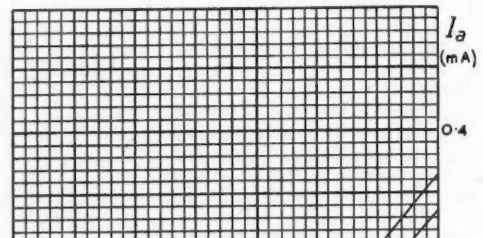


Fig. 4 (*top, left*). **Variation of I_g with I_a and V_a in an EF37 valve**

Fig. 5 (*above*). **Cathode Follower**
V_a (b) = 260 R_k = 33,000 ohms
R_g = 0 and 5600 megohms

Fig. 6 (*left*). **Effect of anode load**
V_a (b) = 150 R_a = 100

tion with source impedance very small. It must be emphasised, however, that while the cathode follower permits the use of very high resistance, it does not in any way reduce the grid current, which will be the same as that obtained with a normal circuit operating at the same anode voltage and current. Whether the current is detrimental or not will depend solely on its effect on the source used. The cathode follower circuit has an additional advantage in that the negative feedback gives a reduction in the effective time constant of the input circuit (*see* Ref. 4).

Another method of obtaining stable operation with high grid leaks consists simply in the inclusion of a high resistance anode load. Then, since the ionisation current is proportional to V_a^2, it follows that the slope K of the I_g/I_a curve is considerably reduced.

It can be shown that the ionisation current reaches a peak at a value of I_a equal to $1/3\ V_{a(b)}/R_a$ where $V_{a(b)}$ is the line voltage and R_a the anode load, and between this point and the point where $I_g = 0$ the slope of the curve is such that a positive input impedance is obtained and the valve will not go unstable. (*See* Fig. 6).

As with the cathode follower, this circuit does not give any reduction in the grid current flowing, but it has the advantage that the gain of the valve is not lost, as is the case with the latter circuit. Both circuits provide a certain amount of compensation for variations in the grid current itself.

The only circuit by which the grid current can be reduced to proportions equivalent to those of the electrometer triode is the one in which the grid current is completely blocked by means of a high insulation series grid condenser.[5] In this case the valve can, of course, only be used on A.C. or as a zero indicating device on D.C. in conjunction with a tapping key.

The valve settles down to the point of the I_g/I_a characteristic at which the grid current is zero, Point D on Fig. 1, and will always return to this point if disturbed, provided that the leakage from the grid is kept very small.

The input impedance of this arrangement is determined by the rates of change of the negative and positive grid currents which are exactly cancelling out one another at point D. Of these, the ionisation current is rising slowly compared with the primary current and the impedance is therefore determined mainly by the latter. The circuit then approximates to that of a diode working at a very low signal level

and under these conditions the impedance can be expected to be of the order of 100 megohms when $I_g = 10^{-9}$A. max.

The arrangement appears to work quite satisfactorily, but special precautions must be taken to keep the leakage from the grid low and constant if it is required to preserve the D.C. level in the output, since any increase in the leakage current from the grid will cause the operating point to move away from point D on the curve. Accordingly, a valve with very high resistance leakage paths and low grid emission should be chosen for the purpose. The ionisation being of only secondary importance in that it will determine the input impedance obtained.

If an instrument employing a valve in this circuit is required to indicate A.C. only, or even when it is used with a tapping key to indicate zero D.C., it is not necessary to preserve the D.C. in the following amplifier and in this case slow variations of the operating point on the grid of the input valve will not have any noticeable effect on the output and it is not necessary therefore to take so many precautions as regards leakage on the input grid.

The arrangement would appear to be the only one which is capable of giving a performance as regards grid current, comparable with that of the electrometer triode, although the input impedance on A.C. of the latter will be some 10^6 times greater.

With a perfect capacitor on the input grid the current flowing from the source will, of course, be zero and the slope of the valve can be considerably higher than that of the electrometer triode. The chief disadvantage is that a direct reading instrument cannot be designed to indicate D.C., when using this arrangement. A possible solution of this difficulty is to convert the D.C. into pulses by means of a vibrating contact and then to amplify these in a normal amplifier using an A.C. instrument or valve voltmeter to indicate the output.

A method somewhat similar to this was the one actually used to obtain the measurements given in this article.

Conclusion

For use in circuits where the grid impedance will not exceed some 100-200 megohms this type of valve can be safely used with reduced H.T. and preferably a heater voltage of about 5 volts, provided that a grid current of, say, 10^{-10}A will not cause any undesirable effects on the input circuit. For use with impedances of several thousand megohms in the grid circuit, both the cathode follower and high anode load circuits can be recommended; the grid current in these cases being of the same order as above.

If, however, the grid current is detrimental to the input circuit, *e.g.*, due to polarisation effects, then the floating grid circuit will have to be employed when it is desired to use ordinary valves.

It is not possible to obtain a performance from these valves which will compare with the special valves designed for electrometer circuits, but there are nevertheless applications in which they can safely be used and it is hoped that these notes will be of some help in choosing suitable operating conditions.

Acknowledgment

The author wishes to express his thanks to the Mullard Radio Valve Co. for permission to publish this article, and to members of the Valve Measurement and Application Laboratory for helpful suggestions.

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FUTURE MEETINGS

The Physical Society

International Meeting in London

The Acoustics Group in association with the Royal Institute of British Architects, is holding a three-day international conference on Noise and Sound Transmission on July 14, 15 and 16. This is the first major international discussion of the subject for many years, and a considerable number of papers will be read by European and American investigators in addition to the contributions from this country.

The meetings will be held in the Jarvis Hall of the Royal Institute of British Architects, 66 Portland Place, London, W.1. Morning meetings will be at 10 a.m. and the afternoon sessions at 2.30 p.m. The sessions will be open to all who are interested, who should inform the secretaries which meetings they expect to attend.

It is hoped to make available beforehand summaries of the papers to be read, and application should be made for these.

Joint Honorary Secretaries, Acoustics Group, The Physical Society, 1 Lowther Gardens, Prince Consort Road, London, S.W.7.

Institution of Electronics Exhibition

The Third Annual Electronics Exhibition organised by the North-West Section of the Institution of Electronics will be held at the College of Technology, Manchester, during the three days July 20, 2.30 p.m. to 9 p.m., July 21, 10 a.m. to 9 p.m., July 22. 10 a.m. to 9 p.m.

There will also be an exhibition of scientific films arranged by the Manchester Scientific Film Society.

ELECTRONIC ENGINEERING will be pleased to meet readers and would-be readers at Stand A.

Admission will be by ticket only, obtainable from *Dr. J. A. Darbyshire, "Melandra," 1 Kershaw Road, Failsworth, Manchester.*

Thames Valley Amateur Radio Transmitters Society

The next meeting will be held at the Carnarvon Hotel, Hampton Court, on July 7. The Secretary is now Mr. A. Mears, of Broadfields, East Molesey.

Cambridge Summer School in Electron Microscopy, 1948

A Summer School in Electron Microscopy will be held this year in the Cavendish Laboratory, Cambridge, from August 18-24 inclusive.

The school will provide a grounding in the theory and applications of the electron microscope. The three leading models of instrument will be used, and discussions held on their special characteristics.

A detailed syllabus and form of application for admission may be obtained from G. F. Hickson, M.A., Secretary of the Board of Extra-Mural Studies, Stuart House, Cambridge.

The Royal Photographic Society Exhibition

The Royal Photographic Society's Ninety-third Annual Exhibition is to be held at 16 Princes Gate, London, S.W.7, during September and October this year.

Further details will be sent, with the appropriate entry form, if application is made to the Secretary, 16 Princes Gate, London, S.W.7.

Germanium Rectifiers

THE crystal rectifier, which in its original form was known to thousands of radio operators in the 1914-18 war, came into its own again in the 1939-45 war. The use of centimetre wavelengths required a sensitive detector with a very low self-capacitance and high stability. These properties were found in the silicon detector, which was redesigned for the special use to which it was put.

The modern silicon detector is enclosed in a capsule approximately $\frac{3}{4}$ in. long and $\frac{1}{4}$ in. diameter, the cat's-whisker being made of tungsten or molybdenum-tungsten alloy. The capsule is filled with wax to stabilise the contact and hermetically sealed.

Although unique in its application to ultra-high frequency circuits, the silicon detector has its limitations, principally in its inability to withstand transient overloads and high voltages. An alternative detector, which is suitable for the lower frequencies in more general use is the Germanium Rectifier, which has also been developed by the British Thomson-Houston Co., makers of the silicon rectifier.

The rectifier, of which a half-section drawing is shown in Fig. 1, is of the same small dimensions as the silicon and consists of a germanium crystal A attached to a plunger B which can be locked in the socket by the grub screw D.

E is the tungsten cat's-whisker, brazed into the metal end-piece F. The whole unit is encased in the ceramic tube G, which is silver-plated at each end and soldered to the end caps. The unit is made only in "wire-ended" form, and care must be taken to avoid overheating the wires when soldering it into circuit.

Fig. 2 shows the D.C. characteristics of the rectifier unit. It is not damaged by sudden or transient overloads of a few milliseconds duration and will regain its normal characteristics almost immediately. An operating life of several thousand hours continuous running may be expected, and the shelf-life is indefinite, judging from the available statistics.

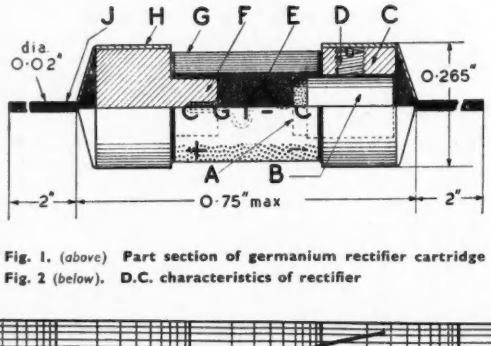
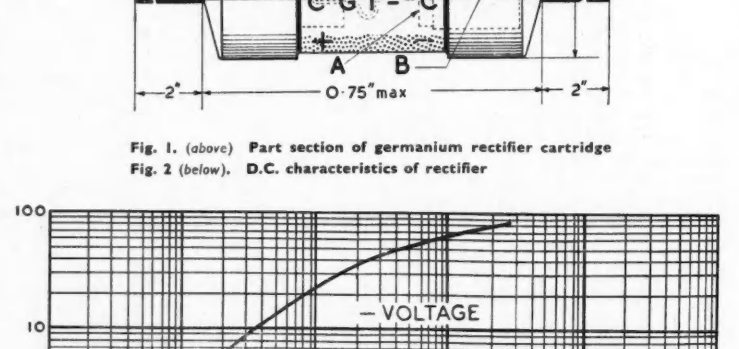


Fig. 1. (*above*) Part section of germanium rectifier cartridge

Fig. 2 (*below*). D.C. characteristics of rectifier



The specification of the Type CG Form 1-C rectifier is as follows:

Max. Reverse voltage, −80 V peak.
Max. Current (Continuous), 50 mA.
Max. Peak Current Input, 400 mA. (limited to 1 sec.).
Resistance at +1 V, 250 max.
Resistance at −50 V, 50,000 min.
Capacitance of 1 unit, 1$\mu\mu$F (av.).
Max. Operating Temp., 100° C.
Min. Operating Temp., −40° C.

In addition to its use as a second detector in low impedance wide-band amplifiers up to 100 Mc/s., the germanium rectifier is very suitable for D.C. restoration and as a means of developing A.G.C. voltage. The absence of heater connexions and the low impedance give it a definite advantage over the more usual vacuum diode, especially where space is an important consideration.

Remedying Sulphation

The Chloride Electrical Storage Co. have recently circulated advice for restoring batteries which have become sulphated through persistent undercharging or neglect. The electrolyte should be emptied out and the battery refilled with distilled water. It should then be given a prolonged charge until the S.G. rises to 1,100-1,150. The water is then emptied out and the battery again filled with distilled water. Charging is then continued until the S.G. rises to a maximum and remains steady. The electrolyte is then finally poured off and replaced with sulphuric acid of 1,250 S.G.

Radio Communication for Aircraft

A Development by E. K. Cole, Ltd.

FOLLOWING a request from the authorities of the Rochford Aerodrome at Southend and in anticipation of legislation regarding "communication facilities" in civil aircraft, E. K. Cole, Ltd., have developed a complete twin channel ground and air installation. It is designed to meet the recommendations of the International Civil Aviation Organisation now in course of implementation by the Ministry of Civil Aviation.

The Aircraft Equipment

The Airborne Transmitter/Receiver has been designed for operation on two frequencies, one of which would be the Civil Aviation Guard frequency of 118.1 Mc/s. The other would usually be the frequency allotted to the local aerodrome from which the aircraft operates and within the band 118-128 Mc/s. Both frequencies are preset and crystal controlled, the only manual controls being (1) Channel frequency selection switch, (2) Send/Receive switch and (3) On/Off switch, making for extreme case of operation.

Sixteen series-operated miniature valves plus rectifier are used. The circuit comprises two crystal multiplier chains, two R.F. and frequency-changing chains and common I.F., detector, L.F., and modulator chain. All the equipment is fully tropicalised. Power is supplied by the 12-volt battery normally carried in all aircraft.

Together with its mounting tray the Transmitter/Receiver, weighing only 13 lb., can be installed in any part of the fuselage. The Control Unit (½ lb.) is best mounted on the instrument panel, but may be installed anywhere within reach of the controller. Provision is made for the use of two sets of microphones and headphone attachments from the Junction Box (½ lb.), thus both pilot and passenger can hear any transmissions. Intercom facilities between pilot and passenger are also available.

The 2-way range of the equipment will vary with local topography and transmitter power, but an indication of range under average conditions is:

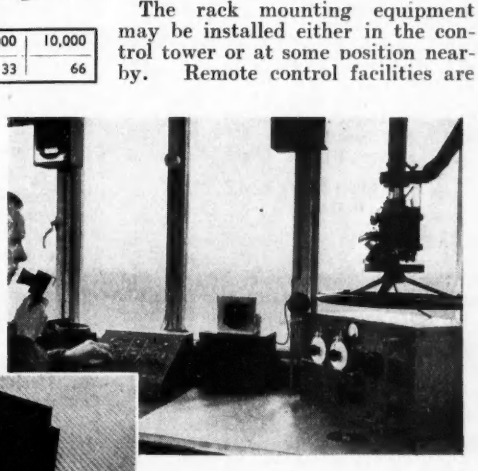
Height (feet)	500	1,000	2,000	10,000
Range (miles)	20	24	33	66

The Ground Equipment

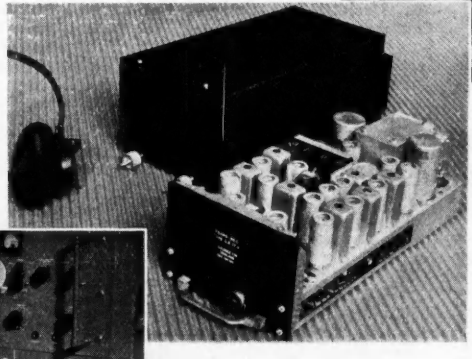
This comprises: (i) Two crystal-controlled V.H.F. transmitters. (ii) Two crystal-controlled high gain receivers. (iii) One control panel. (iv) Two mains-driven power units, all mounted in a self-contained rack assembly.

As with the airborne equipment, the two frequencies will usually be the Civil Aviation Guard frequency of 118.1 Mc/s. and that allotted to the aerodrome itself. The transmitter power output is about 5 watts, the receiver sensitivity approximately 3 microvolts.

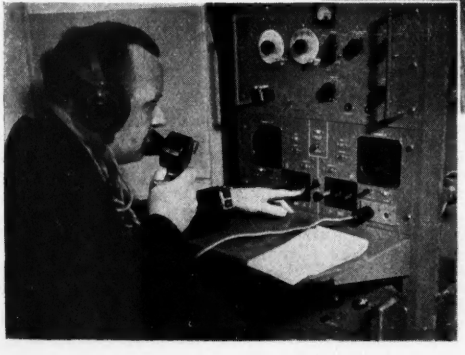
The rack mounting equipment may be installed either in the control tower or at some position nearby. Remote control facilities are available if required, so that control of either channel may be taken over immediately at either the rack or remote end.



Right: **The Control Tower equipment, showing on the left the remote control units. The two-channel crystal controlled V.H.F. receiver and the rotating D.F. aerial system control mechanism are located on the right**



Above: **Chassis of the airborne transmitter/receiver unit. Note the size in comparison with the headphone earpiece**



Left: **Main assembly rack of the aerodrome installation**

The D.F. Equipment

For use in conjunction with the aircraft and ground equipment a complete D.F. installation has also been developed. This comprises a D.F. receiver and two pairs of dipole aerials with calibrated rotating mechanism. It may be tuned immediately and automatically to either of two frequencies for homing aid and to give a precise null indication of an incoming signal. The entire equipment was developed in five months from its inception, a notable achievement.

NOTES FROM THE INDUSTRY

Permanent Export Showrooms in London

Buyers from abroad now have at their disposal a combined club and office in the West End of London, multi-lingual secretaries being among its many amenities.

With the approval of the Board of Trade, International Business Services, Ltd., have recently opened up premises at 14 Arlington Street, Piccadilly, providing showrooms for British firms engaged in the export trade. The particular appeal to provincial manufacturers is that they are provided with a London address and their products are placed in front of overseas business men here on flying visits.

A New Hand Torch

Messrs. Edwards and Co., Ltd., have been appointed sole U.K. export agents for the "Flamemaster" hand torch manufactured by Messrs. Chance Bros. Full details of this torch and the Edwards compressor unit (Type IV), which has been specially designed for operating burners of this type, can be obtained from Messrs. Edwards and Co., Kangley Bridge Road, S.E.26.

New Rider Book

"High Frequency Measuring Techniques using Transmission Lines" is a 64 page book of 8½ by 11 in. pages illustrated with photographs, charts and tables. Its price is $1.50 and is available from the publisher, John F. Rider Publisher, Inc., 404, Fourth Avenue, New York 16, N.Y.

Mr. D. F. Harrison

Mullard Electronic Products, Ltd., announce with deep regret the death at the age of 49 of one of their joint general managers, Mr. D. F. Harrison, who died on June 8, 1948.

Mr. Harrison had served with the Mullard company, in various capacities, for 21 years. He had been under medical attention for 12 months prior to the illness which caused his death, and he leaves a wife and daughter to whom his many friends in the trade extend their sympathy.

Bran's "Radio Valve Vade-Mecum"

In last month's issue it should have been stated that Universal Services are the agents for the 1948 issue. The Modern Book Co. are still the agents for the 1946 edition.

Stratton Price Reduction

Model "640" receiver is now free of purchase tax and due to improved line production it has been possible for its list price to be reduced to £39 10s. as from February 5.

Radio Trades Examination Board

Television Servicing Examination

Preliminary information and the syllabus of the television servicing examination of the Board can be obtained from the offices at 9 Bedford Square, W.C.1. Further information with a list of colleges and schools offering training for the Radio and Television Servicing Examinations will be issued in September.

Training of Telecommunication Engineers

Starting next September at Norwood Technical College, the L.C.C. is to provide a new course to train young men for careers in electronics and telecommunications engineering. It is being arranged with the full support of the radio industry, and, during the two years of the course, the students will have at least six weeks' practical experience with one or more firms producing telecommunications equipment.

Further information can be had from the Principal, Norwood Technical College, Knights Hill, S.E.27 (telephone GIPsy Hill 2268).

Instructional Courses in Servo Mechanisms

Sponsored by a Ministry of Supply Technical Committee, a series of lectures on the principles and application of servo mechanisms will be given at various training institutions throughout the country. The majority of the applications can be understood by students of second or third year standard.

So far, courses have been scheduled at: Heriot Watt College, Edinburgh, Central Technical College, Birmingham (July 5-9); Northampton Polytechnic, London (July 12-16); King's College, Newcastle (September 1-3). Further particulars can be obtained from these establishments.

Publications Received

Brimar Valve Manual.

Includes diagrams of several amplifiers and selections of formulae used in radio engineering. Price 2s. 6d.

Sen Ter Cel Bulletin SRT.6 Issue 2.

On single-phase medium-current rectifiers. Both publications available from:

Standard Telephones and Cables, Ltd., Footscray, Sidcup, Kent.

M. Watts, 38 Chapel Avenue, Addlestone, Surrey.—Retail and Trade lists of available radio components and test equipment.

Baker Research Laboratories, Ltd., 9 Mary Street, London, E.16.—Publication No. SJB/SRG/C.13a/4248 on "The Applications of Colloidal Graphite Dispersions" by I. C. P. Smith, B.Sc., F.R.I.C.

Aerialite Ltd.

Messrs. Aerialite, Ltd., of Castle Works, Stalybridge, Cheshire, have taken over the business of Victor H. Iddon, Ltd., Wythenshawe, Manchester, manufacturers of "Nettle" switches, lampholders and electrical accessories.

A. H. Hunt, Ltd.

Mr. Cecil Whiley, of 54-60 Whitfield Street, London, W.1, has been appointed a director of the company.

Audix Changes of Address

Audix B.B., Ltd., announce that their new factory at Hockerill Works, Bishops Stortford, Herts., is now operating. All correspondence should be sent to this address until the London sales office is opened.

Murphy Radio, Ltd.

As a step in the expansion of Murphy Radio, Ltd., the present company will go into voluntary liquidation, and the whole of the obligations and assets will be transferred to a new company of exactly the same name, but with an authorised capital of £800,000. The goodwill and personnel of the company are unchanged.

Clix Radio Components

As from April 1, 1948, the sales of Clix radio and television components manufactured and hitherto marketed by British Mechanical Productions, Ltd., are being handled by the General Accessories Co., Ltd., of 21 Bruton Street, London, W.1, which is the wholly owned subsidiary of British Mechanical Productions, Ltd., and is their selling organisation through whom all Clix products, in future, will be marketed.

Bulgin Catalogue

Under "Publications Received," mention was made last month of the Bulgin catalogue (List 176) which was stated to be available at 6d. Messrs. Bulgin have asked us to state that these catalogues are at present restricted to the radio trade, owing to the limited supply. A catalogue for the individual user of Bulgin products is in preparation and names and addresses of applicants are being filed for future notification. Apologies to readers who have been misled by the original notice.

Cambridge Electrical Components

Cambridge Electrical Components, Ltd. (CELCO), of 21a Union Lane, Cambridge, have taken up the manufacture of high stability carbon resistors (Grade 1). A range from 10Ω to 10 MΩ is available in five wattage ratings: ⅛, ¼, ½, 1 and 2 W, with standard tolerances of 1, 2 and 5 per cent.

Appointment of Scientific Advisory Committee

The B.B.C. has appointed a Scientific Advisory Committee whose terms of reference will be: "To advise on the British Broadcasting Corporation's scientific research and its correlation with external activities in the same field."

The following have accepted invitations to serve on the committee:—Chairman: Sir Edward Appleton, G.B.E., K.C.B., F.R.S., Secretary, Department of Scientific and Industrial Research. Vice-chairman: Sir John Cockcroft, C.B.E., F.R.S., Director, Atomic Energy Research Establishment. Other members: Dr. H. G. Booker, Christ's College, Cambridge; Professor Willis Jackson, Imperial College of Science and Technology; Dr. R. L. Smith-Rose, Department of Scientific and Industrial Research, and Professor F. C. Williams, O.B.E., Electro-Technical Laboratory, Manchester University.

The Electron in Theory and Practice

Sir Edward Appleton, Secretary of the Department of Scientific and Industrial Research, delivered the Second Dunn Memorial Lecture to the Society of the Chemical Industry in Newcastle on June 1, 1948, on "The Electron in Theory and Practice."

"In conjunction with the Ministry of Supply and a number of Research Associations we in D.S.I.R." Sir Edward Appleton said, "have recently been paying a good deal of attention to possible industrial applications of electronics. We have formed an Advisory Panel under the chairmanship of Sir Charles Darwin, Director of the National Physical Laboratory, which aims at bringing together the research worker, the supplier and the user, and, in addition, groups have been formed at T.R.E. and the National Physical Laboratory to examine industrial problems at first hand with a view to suggesting how electronic equipment could be employed in their solution. These acticities, in the long run, should help to step up the volume of production, improve quality and release men and women now engaged in routine operations for tasks usually more congenial and calling for a greater exercise of human intelligence."

The Use of Radar at Sea

A recent meeting of the International Conference on Safety of Life at Sea approved a new agreement to replace the International Convention of 1929.

It was recommended that Governments should regularly exchange information on radio and radar aids to navigation and should encourage the use of radar installations on ships.

The report on radio telegraphy and telephony approved the fitting of radio telegraph installations on all passenger ships, irrespective of size, and all cargo ships over 1,600 tons, unless specially exempted.

Demagnetising Valves

As a Cure for Residual Ripple

SIR,—During the last few years we have been developing methods of heating with raw A.C. the input stages of high-gain balanced low-frequency amplifiers for biological purposes. In previous communications (ELECTRONIC ENGINEERING 19, 221: 1947, 19, 81, 1947) it was pointed out that the "electrostatic" component of the ripple from A.C. heaters can be reduced by (a) using a screened heater winding; (b) lowering the voltage of the supply to, say, 3.5 to 4V for 6-volt valves; (c) biasing the heater circuit through a "humdinger." The "magnetic" component can similarly be reduced by lowering the heater current to below a critical value.

When, in spite of these precautions, residual ripple is troublesome, this is usually due to the magnetic component, which cannot of course be balanced out with the humdingers, and is worse when the input grid impedance is low. There is great variation between individual valves in this respect and careful selection has been necessary; when using a type of valve which is satisfactory in other ways (*e.g.*, EF. 37), up to 50 per cent. have been found intolerable because of magnetic heater ripple. Until recently we have had no explanation of the great variation between individual valves, though we noticed that there was also considerable variation between batches obtained from different sources and with different histories.

In the course of setting up some hundreds of these amplifiers the problem of selecting input valves became so acute that we were forced to look for the source of the trouble. Now some years ago, we noticed that this residual ripple could often be eliminated by placing a small permanent magnet a few inches from the input valves in an empirically determined position and orientation. This solution, though satisfactory for a single channel, did not commend itself for multi-channel instruments; moreover, we were unable to decide why the effect should be produced.

Continuing on these lines, however, we found that if the magnet was brought very close to the valve and then removed, the ripple invariably became worse and remained so, the conclusion being that magnetisation of the valve electrodes had a deleterious effect. We accordingly tried de-magnetising unsatisfactory valves in a decreasing AC field, and found that even the worst offenders could be "cured" in this way, whether they had previously been deliberately magnetised or not.

As a further check we have investigated the magnetic properties of "good" and "bad" specimens and find that "good" valves induce no current whatever when moved in and out of a coil, whereas "bad" ones generate considerable currents, in proportion to the amount of magnetic ripple which they produce as input amplifiers.

As a result of the de-magnetisation procedure the proportion of ripple rejects has been reduced to zero, so that selection need now be made only on the basis of microphony and "noise." It is to be expected that during manufacture and storage of valves, they would have ample opportunity to become magnetised either in the earth's field or from ferrous materials.

We should be very grateful to have a rigorous explanation of this effect and references to it in the literature, of which we have so far discovered none.—Yours faithfully,

W. GREY WALTER, D.Sc.
H. W. SHIPTON, Assoc.Brit.I.R.E.
W. J. WARREN.
Burden Neurological Institute.

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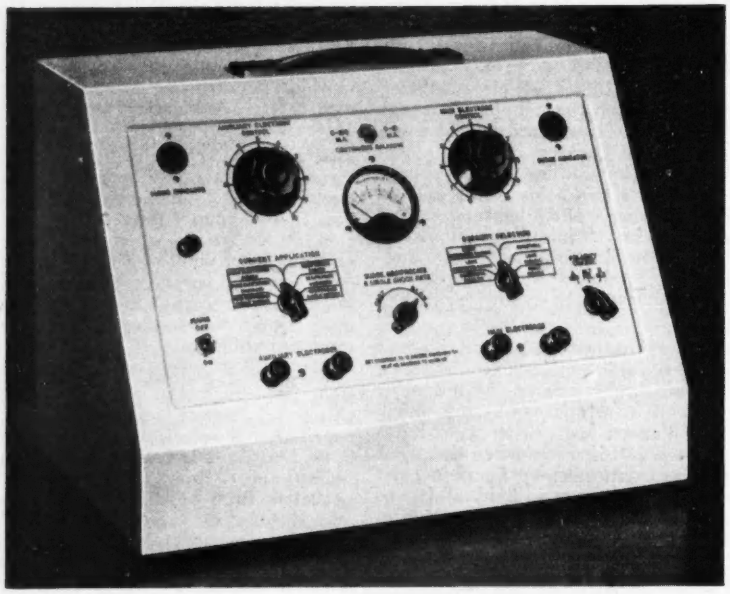
Electronic Equipment

A monthly record of British electronic apparatus, components, and accessories, compiled from information supplied by the manufacturers. Many of the items were shown for the first time at the recent industrial exhibition, and a further selection will appear next month. Enquiries should be sent to the manufacturers at the addresses given, and it would be appreciated if this journal were mentioned as the source of information



Electrical Treatment Unit

THIS unit has been designed to provide all the types of current required for physio-therapy and massage, and is also capable of being adapted to other forms of electrical treatment.

The currents available are : Sinusoidal 50 c/s. A.C. from 0-80 V_{PK} ; continuous current variable up to 100 mA. and interrupted unidirectional pulses of 100 mS. and 10 mS. ; square-shaped sharp pulses of 1 mS. and 0.1 mS. All the currents can be "surged" or interrupted.

Dimensions : 17½ in. long, 11 in. deep, 12½ in. high. White enamel finish. Mains operated from 90-240 V.

Multitone Electric Co., Ltd., 223-227, St. John Street, Clerkenwell, E.C.1.

Laboratory Frequency Standard

A PORTABLE frequency standard embodying a quartz crystal oscillator operating at 1 Mc/s., accurate to within 50 parts per million. A series of multivibrator circuits is energised from this crystal, giving frequencies of 100 Kc/s., 10 Kc/s., and 1 Kc/s. It is also possible to obtain calibration points at harmonics, extending to 50 Mc/s.

An internal modulation circuit is also provided.

Furzehill Laboratories Ltd., Boreham Wood, Herts.

Correction

The description of the Elliott Miniature Relay in last month's record was accompanied in error by a photograph of the Shipton Polarised Relay. This is shown on the next page with its correct information.

Photoelectric Equipment

BRITISH Electronic Products (1948) Ltd., have recently completed development of a new range of photoelectric control devices designed particularly for flexibility of operation.

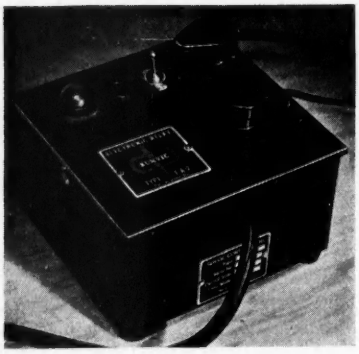
The following units comprise the present range of standard equipments :

1. A compact, rugged light source unit available with various types of lens system and adaptable to many applications.
2. A photocell head unit of tubular drawn steel construction with all components hermetically sealed internally. This unit, which can be provided with photocells having various characteristics, can also house a head amplifier when long cable runs make this necessary.
3. A main unit providing all the necessary supplies and housing the control circuits required for a specific operation. This may be counting, straightforward switching, etc., and a number of standard types are available for common applications.

Pyrotenax cable has been found most suitable for interconnection arrangements and can be supplied with the equipment if desired.

For many applications, a more simple single unit housing both photocell and control circuits can be utilised and B.E.P. have developed a lower-priced unit for use with a standard light source to meet such requirements.

British Electronic Products (1948) Ltd., Brereton Road, Rugeley, Staffs, England.



Electronic Relay

THIS relay was developed for use with light contacts and needs only a few microwatts to operate. It is used in conjunction with a thyratron, the opening of the control contacts causing the thyratron to discharge through the heater winding of a hot-wire vacuum switch, which closes the main load circuit.

Overall dimensions $6\frac{1}{2}$ in. by $6\frac{1}{2}$ in. by $3\frac{1}{2}$ in. Weight $7\frac{1}{2}$ lb. Price complete, £14 10s. 0d. Photograph above.

Sunvic Controls Ltd.,
10 Essex Street, Strand, W.C.2.

Industrial Control Valves

ECC.33.—A medium-impedance double triode with separate cathodes. V_h 6.3, r_a 9700, g_m 3.6 mA/V.

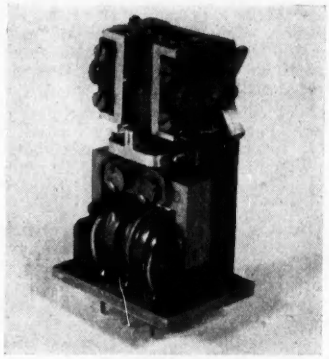
LSD.3.—Xenon-filled flash tube with a maximum energy of discharge of 100 joules. Duration of flash 1/5,000 sec. Maximum voltage 2,700.

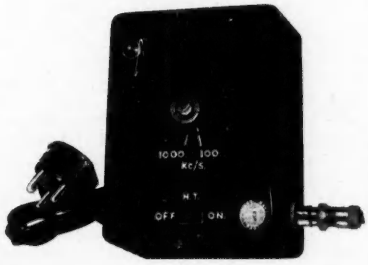
Mullard Electronic Products Ltd.,
Century House, Shaftesbury Avenue,
London, W.C.2.

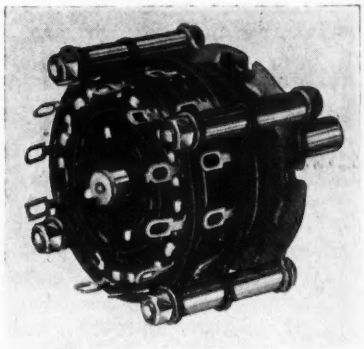
Polarised Relay

THE Shipton Relay is a hermetically sealed polarised relay with two change-over contacts, side stable, and was developed in conjunction with the A.S.R.E. The sensitivity is .085 mW., and the travel of the armature .004 in. Contact pressure (unenergised) 7.5 gm. each contact. Life, 5,000 hours at 400 c/s. continuous working. Dimensions : $3\frac{5}{16}$ in. high by $1\frac{5}{8}$ in. wide by $1\frac{3}{16}$ in. deep. Photograph below.

E. Shipton & Co.,
Ferndown, Northwood Hills, Mddx.







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A COMPLETE range of patented design 12-way and 18-way ganged switches for radio, electronic, or instrument use.

The switches are one-hole fixing, and the overall room occupied behind the panel is $1\frac{1}{2}$ in. square.

Ganged switches up to 4 decks are available in both 12 and 18-way switches. All contact surfaces are heavily silver plated.

Taylor Electrical Instruments Ltd.,
419/424, Montrose Avenue, Slough, Bucks.

"Eddystone" Crystal Calibrator

THIS instrument has been made as compact as possible, so that it can be placed on or alongside a receiver without taking up much room.

The circuit uses a miniature valve and has been designed to provide high harmonic output. The 100 kc/s. harmonics are usable up to 30 Mc/s., and the 1,000 kc/s. harmonics up to 60 Mc/s. The two separate vacuum mounted crystals are ground to a tolerance of plus or minus 0.01 per cent., giving extremely high accuracy of calibration.

A miniature mains transformer and metal rectifier provide H.T. and L.T. two switches are fitted—one for changing from 100 kc/s. to 1,000 kc/s. harmonics, the other to cut off H.T. but leaving the heater on so that the unit can be brought into immediate operation.

Stratton & Co., Ltd.,
Eddystone Works, Birmingham, 31.

Low Frequency Oscillator

THIS instrument embodies an R-C oscillator circuit with a compensating resistance to maintain the output substantially constant at all frequencies. The range is 25 to 100,000 c/s. in four ranges : 25-250 ; 100-1,000 ; 1,000-10,000 ; 10 Kc/s.-100 Kc/s. with individually calibrated scales.

Output impedances are 6,000 or 600 ohms, and the output is adjustable to a maximum of 25 V at 6,000 ohms and 1.0 V at 600 ohms.

Output voltmeter is provided, and the total harmonic content does not exceed 1 per cent. at maximum output.

Dimensions : $15\frac{1}{4}$ in. by 10 in. by $7\frac{1}{2}$ in. deep. Finish : Blue crackle. Weight : 17 lb. Price : £45 net., F.O.B. for export

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BOOK

Electronic Circuits and Tubes

Staff of the Cruft Laboratory, Harvard University. 933 pp. Numerous figs. in text. (McGraw-Hill Co. 45s. net).

THE authors of this volume were engaged in the pre-radar training of U.S. Army and Navy officers, and it is a carefully edited collection of their lecture notes for the course. In the foreword Prof. Chaffee states that the treatment is suitable for juniors or seniors of colleges and engineering schools specialising in the study of communications engineering or electronics, and a knowledge of mathematics through (sic) calculus, and of electricity and magnetism, is assumed.

The general tone of the book might be described as business-like and concise. Very few words are wasted, and most of the important basic material is presented in a way which requires the utmost concentration from the reader.

This is not necessarily a criticism, but an acknowledgment of the immense difficulties under which a teaching staff work when they have to compress the contents of a course normally lasting several months into a few weeks. The same difficulty was experienced in this country in the intensive training of radar operators, and the trouble only arose later when the student found that rapid absorption of information in tabloid form was not an adequate substitute for the more leisurely process of digestion.

If, therefore, the words "lecture notes" are kept in mind, the use and scope of the book will be given proper perspective. After introductory alternating current theory, the details of circuit elements and circuit response are given, with notes on measurement. Then follows networks and impedance matching, transients and coupled circuits, filters and Fourier analysis to complete the circuit theory.

The next portion (Chapter 10 onwards) deals with thermionics, valves, the C.R. tube, and the use of electron tubes in circuits. Signal analysis (Chapter 18) introduces pulse theory, and then the application of the pulse—modulation — reception — and finally, timing circuits.

From this brief catalogue it will be seen that the book covers the widest possible field. The longest chapter, that on Radio Receivers, occupies only 40 pages, and is typical of the feats of compression which have been performed by all the authors. The corresponding feat of expansion on the part of the reader can be done by reference to the other well-known McGraw-Hill books of which Prof. Chaffee's own is an example.

It is a pity that the mathematical viewpoint should predominate throughout, though this is no doubt due to it being easier to express a statement in mathematical form, and less space-occupying. For example, the common applications of the cathode-ray tube are classified as:—

1. Plotting e_y *v.* e_x
2. Plotting i_y *v.* e_x, or *vice versa*
3. Plotting e_y *v.* t_x, or i_y *v.* t_x
4. Plotting e_y *v.* f_x, or i_y *v.* f_x

and so on, which must be unique in its dry statement of the possibilities of a beautiful instrument.

A chapter which the reviewer enjoyed most was that on Timing Circuits, possibly because it was more descriptive and less mathematical. This gives an excellent and comprehensive review of oscillators, time base circuits, and the later special forms of circuitry adapted for radar work. The appendices at the end of the book fill up some gaps by giving a summary of mathematical theory and electricity and magnetism. The symbols and abbreviations used throughout, which are explained in an appendix, are logical and good. It is to be hoped, however, that the attention of American authors will be drawn to the recent list of symbols for radio valve parameters issued by the B.S.I., as these seem more reasonable than some of the more unusual subscripts used in American texts.

As the basis of an extended course on electronics this book serves a useful purpose, and with its companion volume "Transmission Lines, Antennas, and Wave Guides" should form a valuable reference for lecturers in radio generally.

G. PARR

Science at War

(H.M. Stationery Office, 2s. 6d. net.)

This is a popular book issued by H.M. Stationery Office to show how the armed forces were helped by science. The bulk of the information covers four aspects of research: Radar, Operational Research, the Atomic Bomb, and Science and the Sea.

The presentation of scientific facts in a manner comprehensible to the lay mind is not easy, yet in "Science in War" the authors have made the subjects clear to the reader with little technical knowledge. This has been done by the method employed. First the problem in each case is stated both from the national point of view and that of the fighting men. After this the method by which the scientists attacked the problem and the results they achieved are described in simple language, well supported by photographs and drawings. The book can be thoroughly recommended.

REVIEWS

Electrical Materials

By E. Molloy, George Newnes., 111 pp. 5s. net.

THIS is a reference book in which information is given on the composition, properties and applications of conducting, insulating and magnetic materials as used in the electrical industry. The first three chapters deal with the conductors and contain some useful data of electrical and mechanical properties and indicate the fields of application of the various materials.

The chapter on ferrous metals is not so informative and would be improved by the addition of magnetisation curves for the materials met with in the construction of machines and transformers.

The chapter devoted to insulating materials occupies half the space in the book and the information includes some physical and chemical properties. The uses and applications of oils, waxes, resins, varnishes and enamels are given in considerable detail as also the the solid insulating materials and coverings for wires.

The book concludes with a summary of British Standard specifications relating to electrical materials.

W. H. D.

Understanding Vectors and Phase

J. F. Rider and S. D. Uslan. (John F. Rider, Publisher, Inc. 153 pp. + V. Price 99 cents.)

WE are told by the publishers and by the authors in their introduction that this book was written for the man lacking technical or engineering training such as the radio serviceman, the radio amateur or the radio technician. The chapters include single and multiple vector representation; resolution of vectors; addition, subtraction multiplication and division of vectors, with a final chapter on some radio circuit problems.

There is no attempt to employ any algebra or trigonometry and geometry is confined to the statement of the theorem of Pythagoras; the book is solely concerned with the representation of voltages and currents and their phase relationships by means of vectors. The diagrams are well set out and the accompanying text gives clear explanations so that the reader obtains a good visual picture of what is happening in a circuit in a qualitative sense. Sooner or later, however, the radio serviceman or technician will surely want a quantitative result and then how much more laborious his work becomes without a knowledge of some simple algebra and trigonometry!

W. H. DATE

Elements of Radio Servicing

(Trade Edition)

William Marcus and Alex Levy. (McGraw-Hill Book Co. Inc. 475 pp. Price $4.50.)

THE British service engineer who is essentially practical and mechanical in his outlook and has, perhaps, obtained his present knowledge from receiver servicing and bitter experience rather than from theoretical study, will find this book a useful companion. Many difficult problems confronting the authors of such a work have been very neatly side-stepped by ignoring the details of any particular receiver current in America, and basing the entire treatment of the subject on a typical or standard circuit " five plus one " superheterodyne.

The reader is conducted step-by-step from the power supply unit to the aerial, and is given at each stage a very thorough and, sometimes, repetitive summary of the more probable causes of failure. The system of substitution of a known good component for the suspected faulty one is relied upon to a very great extent. This is, of course, common sense and in the hands of a mechanic with a flair for " trouble-shooting " can yield results in the minimum time.

Now " time " is the most expensive item in a serviceman's bill to his customer but, in fact, rarely appears as such on his invoice. This is because by bitter experience the serviceman has discovered that the one thing to which a customer objects is paying him for his experience and knowledge in tracing the fault which is " time." The customer seems to be quite happy if the item appears in another guise—valve, choke, transformer or what you will. A most regrettable fact, encouraging questionable tendencies but justifiable under the circumstances.

In addition to the wholly practical and commonsense approach to the problems, there is a very well selected range of apt questions at the end of several chapters to which, most unfortunately, no corresponding answers are given. The next edition would be greatly improved by this addition.

The fact that it is written entirely around American receivers does not in any way detract from its usefulness to the British service-mechanic. The entire omission of television receivers from the book indicates that the authors felt that it was too big a subject for satisfactory treatment in a few chapters. Nevertheless, it is a pity because with the growth of numbers of television sets in Great Britain, the serviceman here would welcome a textbook on this subject on the lines of the one under review.

If there are any misprints, they are not apparent at first reading, and the use of American terminology is not at all obvious except in the use of the term " gimmick coil."

C. C. MCCALLUM

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ABSTRACTS OF ELECTRONIC LITERATURE

THERMIONIC DEVICES

Measurement of the Ionisation and Deionisation Times of Thyratron Tubes

(M. Birnbaum)

Results of investigation into the ionisation and deionisation times of several thyratron valves are presented. To measure the ionisation time, a rectangular pulse with rise time of less than 0.01 microsec. was used together with a synchroscope. The deionisation-time characteristic was obtained by bringing the thyratron into conduction, maintaining the anode potential steady at a value below that of the cathode, and measuring the maximum voltage that may be suddenly applied without causing re-ignition. Valve types tested include the 2C4, 884, 6D4, 3C45, 2D21, and 2050.

—*A.I.E.E. Tech. Paper No.* 48-88, December, 1947, p. 13.*

Secondary Emission—I

(L. R. Koller)

In this, the first article of a series, a brief description of the phenomenon of secondary electron emission is given. Its measurement in triodes and that of primary and secondary emission in an electron-gun valve are described. The effects of electron potential, surface contamination, angle of incidence and use of differing metals, semi-conductors, compounds and alloys under bombardment by electrons are studied. Yields for several compounds are tabulated.

—*Gen. Elec. Rev.*, April, 1948, p.33.*

Some Photoelectric Thresholds for Geiger-Muller Counters with Evaporated Cathodes

(C. A. Ramm)

Measurements with several cathode metals have been made in order to determine the influence of the latter on the photo-electric thresholds of Geiger-Muller counters prepared in a manner similar to that described by De Vos and Du Toit. Gold is shown to have desirable properties for counters with evaporated cathodes. Preparation of the counters and methods of loading the anode wire are described.

—*J. Sci. Inst.*, December, 1947, p.320.*

A New Experimental Electron Microscope

(G. Liebmann)

An experimental universal electron microscope of high magnification is described, which deviates in many ways from known types. The instrument, intended as a self-contained desk model, employs four permanently aligned magnetic lenses and optical magnification. A new type of specimen stage, permitting a quick exchange of specimen, wide-angle stereoscopic observation and direct calibration of specimen position and an improved electron gun are used. The camera head is exchangeable. The instrument can be quickly adapted for electron diffraction observations. Possibilities of further development are discussed.

—*Jour. Sci. Inst.*, February, 1948, p. 37.*

INDUSTRY

New Electronic Equipment for the Rubber Industry

(B. J. Dalton)

Descriptions are given of the application of electronic control to various aspects of the rubber industry, for example, to the weighing of rubber as it is extruded, to controlling the speed of extrusion, to giving a speed range of 10 to 1 with motors driving conveyers, and to the co-ordinating of calender trains for the rubber coating of fabric. Electronic circuits are also used to give accurate speed acceleration, current limiting and emergency stopping of calender motors, and tension control.

—*Elec. Eng.*, February, 1948, p. 119.*

Minimum-Cost Chokes

(T. H. Oddie and J. L. Salpeter)

A design method is developed for chokes carrying A.C. only to enable the most economical dimensions to be found for any given electrical characteristics. Formulae and tables are given for rectangular types of chokes with and without limitations on the stacking height. It is also shown briefly how the method may be applied to chokes carrying D.C. with superimposed A.C.

—*Philips Res. Rep.* 2, August, 1947, p. 281.

TELEVISION

Interlocked Scanning for Network Television

(J. R. De Baun)

The benefits of operating the scanning systems of two or more independent television broadcasting plants in locked coincidence are discussed. The problem of producing locked coincidence is explored, and methods of achieving the desired results are indicated. Some of the possible benefits of using stable (high inertia) frequency sources for scanning systems are noted.

—*RCA Review*, December, 1947, p.651.

Technical Aspects of Television Studio Operation

(R. W. Clark and H. C. Gronberg)

This article describes the operating procedures employed in a television studio for the presentation of a live talent programme. It is divided into two parts, one covering the operation of the technical equipment and the other describing the improvements that have been incorporated in the equipment as a result of operating experience. This latter section includes discussion of camera dollies, lighting, microphones, microphone boom, iconoscope cameras, dialogue equalisation, audio perspective, transcription turntables, communication and cue systems, and the control room.

—*RCA Review*, December, 1947, p.179.

MEASUREMENT

A Mobile Laboratory for Acoustical Work

(W. C. Copeland)

The paper describes a mobile laboratory, mounted on a 5-ton lorry chassis, of dimensions adequate to give comfortable working space, fitted and equipped to enable comprehensive measurements to be taken in the field. The interior layout and the type of apparatus installed is described in detail, and in particular the description of the methods adopted for obtaining mains supplies for the apparatus, the mounting of apparatus to minimise damage by vibration, and the provisions made for carrying long cables may be helpful to workers in other subjects who may wish to construct or have constructed, a mobile laboratory.

—*Jour. Sci. Inst.*, March, 1948, p. 82.

A Direct-Reading Frequency Meter for the Audio and Supersonic Ranges

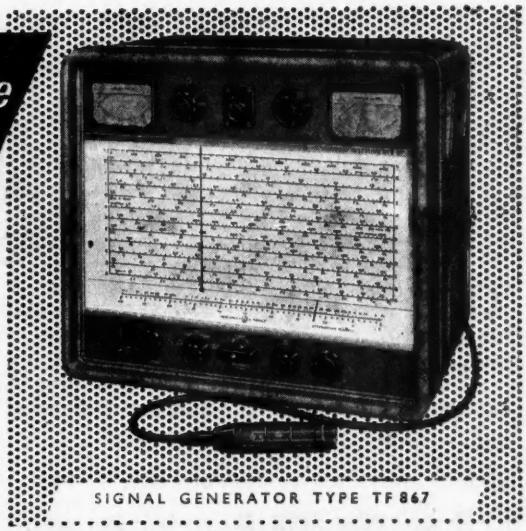
(H. J. Reich and R. L. Ungvary)

This paper describes an electronic frequency meter capable of operating in the range from 20 c/s. to 200 Kc/s. The reading of the instrument is independent of the waveform as long as the input wave does not cross the zero axis more than twice in its fundamental period. For sinusoidal input, the voltage required for reliable operation is less than 0.08 V r.m.s. between the frequencies of 900 c/s. and 200 Kc/s. the sensitivity in the range below 900 c/s. can be readily increased by minor changes in amplifier coupling networks. Over a six-month period the experimental model has shown no change of calibration.

—*Rev. Sci. Inst.*, January, 1948, p. 43.*

* Abstracts supplied by the courtesy of Metropolitan-Vickers Electrical Co. Ltd. Trafford Park, Manchester

On a Generous Scale



In the new Marconi SIGNAL GENERATOR, TF 867, measurement facilities are on a generous scale — including the frequency scale itself ! In this one instrument such features are incorporated as crystal standardisation, freedom from unwanted frequency modulation, deep amplitude or carrier shift modulation and stabilised output level. Range is 15 kc/s to 30 Mc/s, and output variable from 4v to 0.4μV ; calibration indicates true artificial signal e.m.f. irrespective of load.

An integral terminating unit offers source impedances of 75Ω or 13Ω and provides a dummy aerial ; it also shows, on an animated diagram, the exact conditions of circuit. In all, and judged by any standard, Type TF 867 is *demonstrably* the very paragon of signal generators. Full particulars are freely available.

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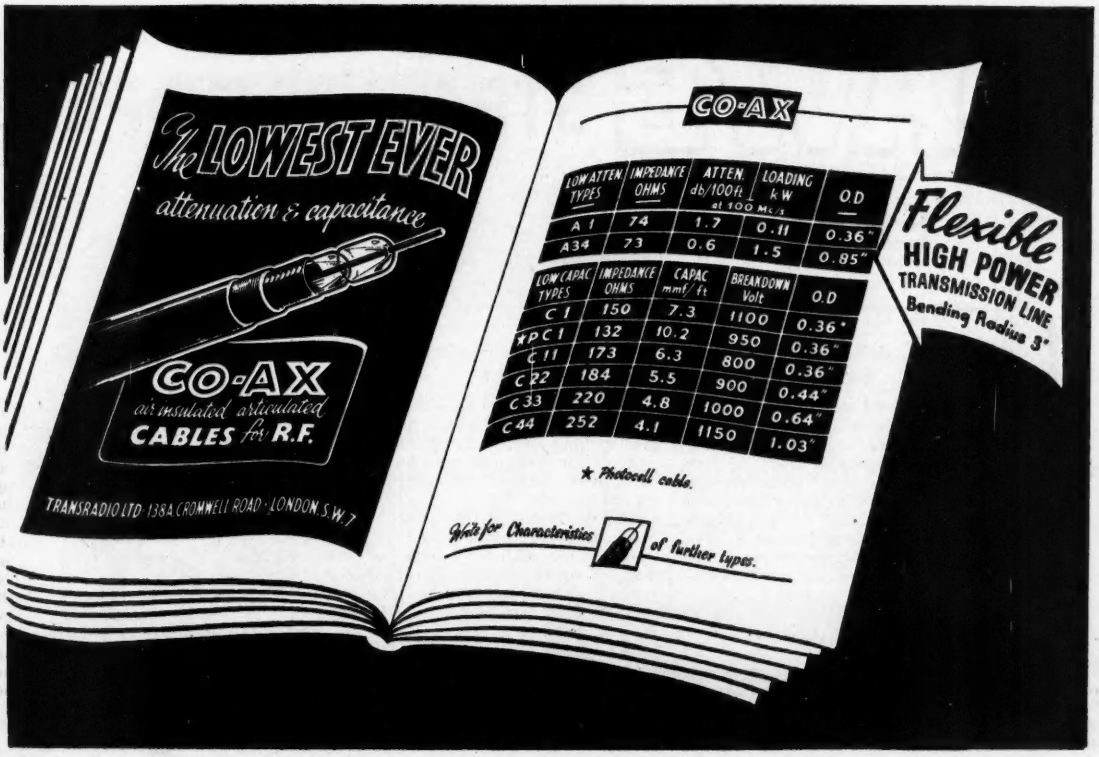

The use of modern high-energy magnetic materials in these instruments gives an exceptionally high torque/weight ratio; and mechanical simplification gives greater reliability, longer life. Full particulars of range on request.

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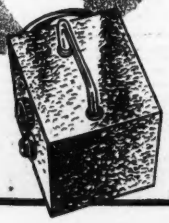

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Continuously variable wirewound
Dissipation, 2 watts
Resistance values, 25 - 5000 ohms.
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UNIT OSCILLOSCOPE

DATA SHEET No 4

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This series constitutes a substantial advance on the equipment normally available in portable form. The output stage consists of four of the latest Mullard E.F.55 Television output pentodes, taking a total H.T. current of 180 mA. with a mutual conductance of 12.0 mA/V.

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For an output of approximately 50 volts R.M.S., typical response is level from 5 cycles to 1.5 Mc/s.; 6 db. down at 5 M/cs. with a gain of 25 and at 3 Mc/s. with a gain of 600.

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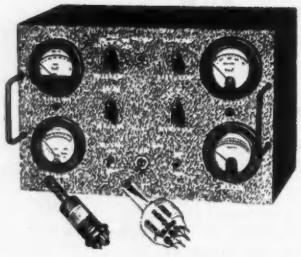
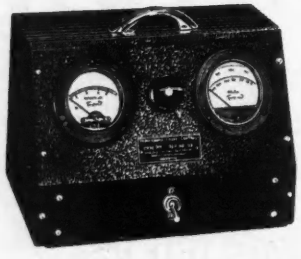
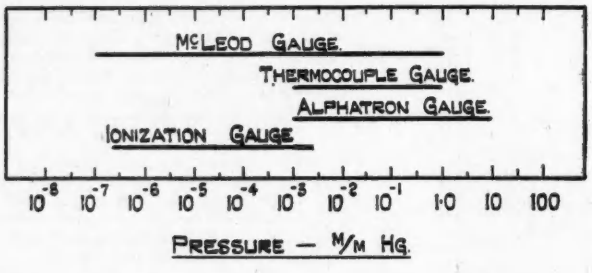


THE B.A.R. THERMOCOUPLE-IONISATION GAUGE CONTROL. The newly developed Thermocouple-Ionisation Gauge Control, complete with Thermocouple and Ionisation Gauges, covers the pressure range from 2×10^{-7} mm. to 1 mm. Hg. Operation is dependable and simple. Ranges are 10^{-3}—1 mm. and 0—5, 0—1.0, 0—0.1, 0—0.01 microns. The unit is removable from its cabinet for incorporation in a central panel.

THE B.A.R. ALPHATRON is an ionisation-type vacuum gauge using the ionising power of alpha particles from a radium source, to measure total pressure of any gas, vapour or mixed atmosphere from 1 micron to 10 mm. Hg with instantaneous linear response. The B.A.R. Alphatron is quickly available from batches now in production.



THE B.A.R. THERMOCOUPLE GAUGE CONTROL is a light, portable instrument that may be carried to any part of a plant or system for vacuum testing. It is compact, rugged and built throughout to withstand hard industrial use.
This unit gives pressure indications over a continuous range from 1 to 1,000 microns Hg. These pressures are read directly on the microammeter which is calibrated both in microns and micro-amperes. By means of increased filament current and special calibration, the unit will indicate pressures up to 2 mm. Hg. The gauge is undamaged by operation at atmospheric pressure.



All of the above instruments are suitable for operating on a 230/250 volt 50/60 cycle supply

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DISCERNING ENGINEERS will not be slow to appreciate the advantages offered by these improved decade capacitance units:—

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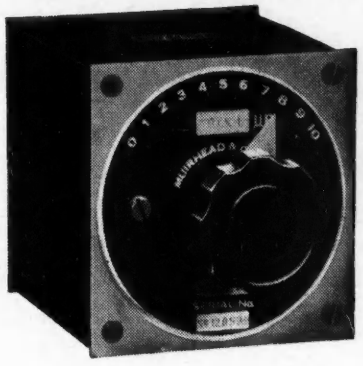
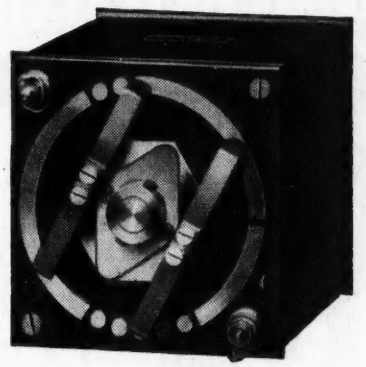
SEALING • Condenser units are completely sealed within the container by an approved sealing compound.





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CONDENSERS • Clamped mica type for long-period stability.

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POWER FACTOR • 0·0005 at 1 kc/s.

TEMPERATURE COEFFICIENT • −20 to +10 parts in 10^6 per °C.

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0·01 μF *in steps of* 0·001 μF	0·1 μF *in steps of* 0·01 μF	1·0 μF *in steps of* 0·1 μF

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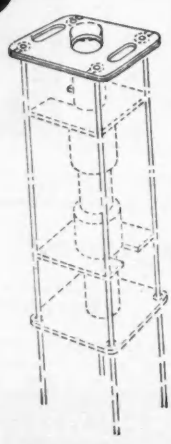
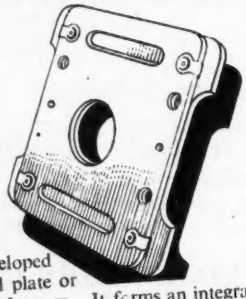


Type SMS. 102 suitable for miniature I.F. transformers ⅝" square.

Type SMS. 202 suitable for standard I.F. transformers 1⅛" square.



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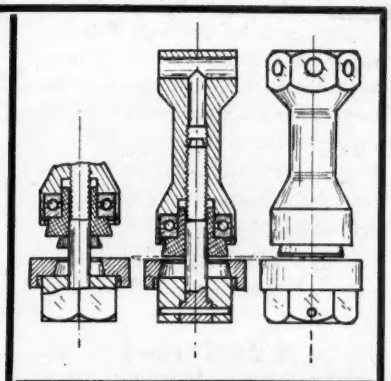
Another, is the provision of an elongated Capstan Nut which enables the tool to punch holes from the inside of the radio chassis. In such circumstances, the holes can be cut quite close to the edge of the panel.



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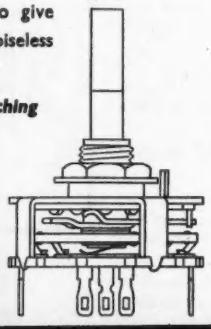

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Answers to some of the questions we are continually asked by letter and telephone

Question 37. *What is the recognised method of making a comparison between different types of anti-interference aerials ?*

Answer 37. The mode of procedure is laid down in B.S.S.905. The original "Eliminoise" curves were prepared by the National Physical Laboratory and have been published frequently and are shown in our literature. We are satisfied that the "Eliminoise" has not yet been beaten on any generally useful frequency.

Question 38. *What is the purpose of the metallised paper wrapping under the wire screen of the "Belling-Lee" twin feeder (Cat. No. L1221)*1, and is it necessary to earth this to the screen at either or both ends ?*

Answer 38. (1) Its purpose is to maintain the characteristic impedance and attenuation loss constant over the life of the cable. Without this metallic paper the braided tinned copper shielding ultimately oxidises, causing an increased resistance at the points of intersection of the braid wires which has the effect of increasing both the characteristic impedance and the attenuation loss.

(2) There is no need to bond the metallised paper to the shield, as its capacity thereto may be regarded as the electrical connection at high radio frequencies. This metallised paper feature is covered by (U.K. Patent No. 559518) of Messrs. Telegraph Construction and Maintenance Co.

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Answer 39. Theoretically there will be small changes in the characteristic impedance at various points along the line. These changes will be related to its proximity to various earthed objects, but at television frequencies the changes are so insignificant that they are immeasurable by any ordinary means. In the case of a feeder with a characteristic impedance of the order of 400 ohms and typified by a spacing of a few inches between conductors, the presence of other incidental conductors closer to the feeder than this, would result in appreciable attenuation.

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*1 L1221 Screened Twin Feeder ... per yard		1 9
*2 "ELIMINOISE" (Regd. Trade Mark) Complete Anti-Interference Horizontal Aerial Kit L308/K	£6	6 0
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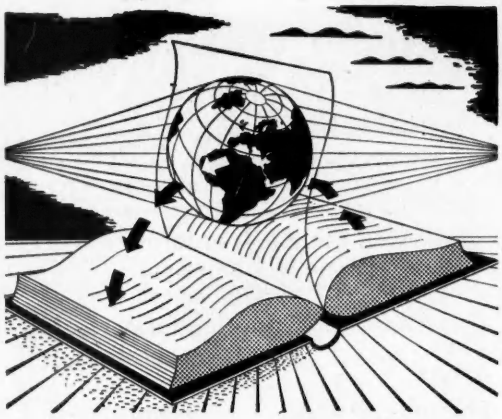

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All at 4d. each. 3/6 per dozen.
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Wingrove & Rogers miniature two gang. 315 pF. max. 10/- each. Ideal for midget receivers.
Split stator. 30 pF. each side. Ceramic insulation. Silver-plated. 1/- each. 3/9 per box of four.

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Mains transformers. 250-0-250 volts 60 mA 6.3 volts 3 amp. Normal primary with screen and voltage adjustment panel. 13/6 each.
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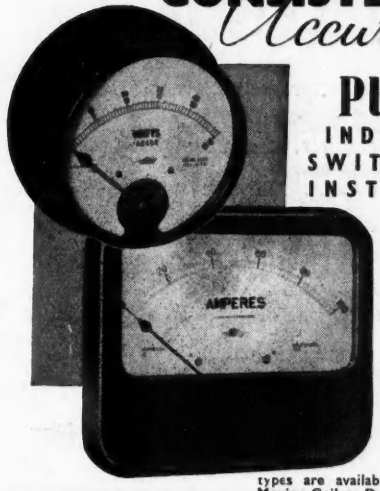

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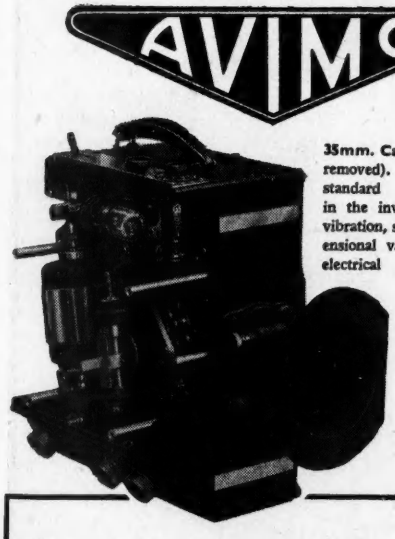

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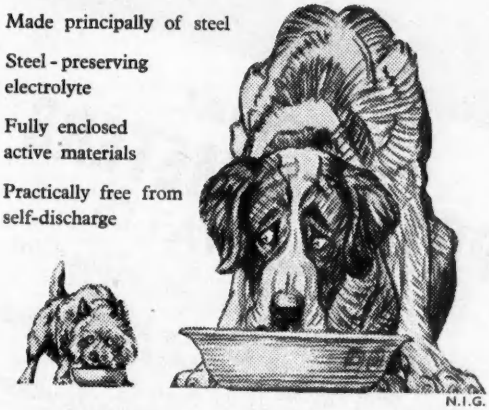

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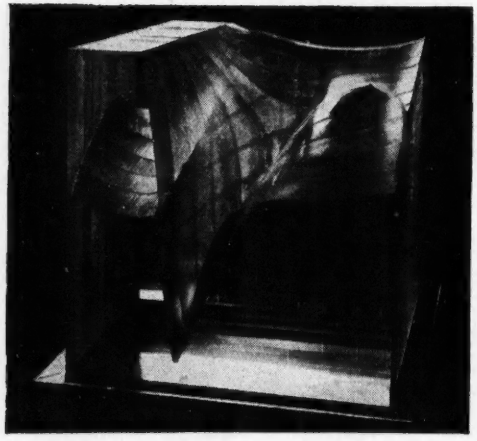

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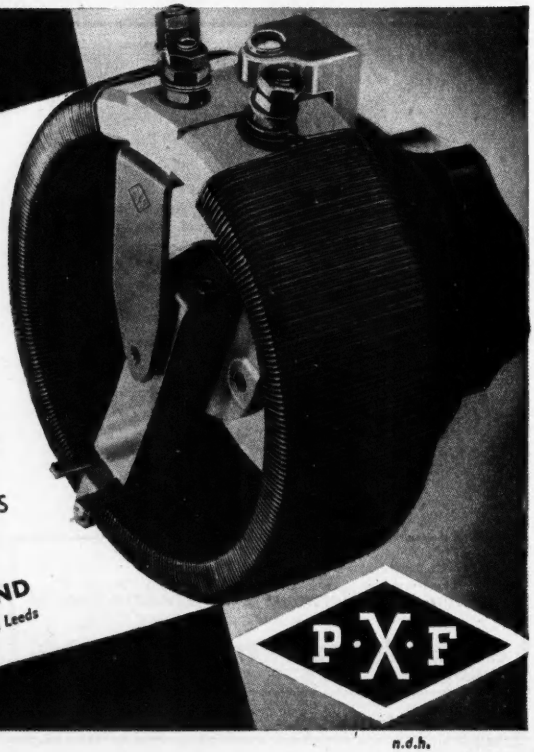

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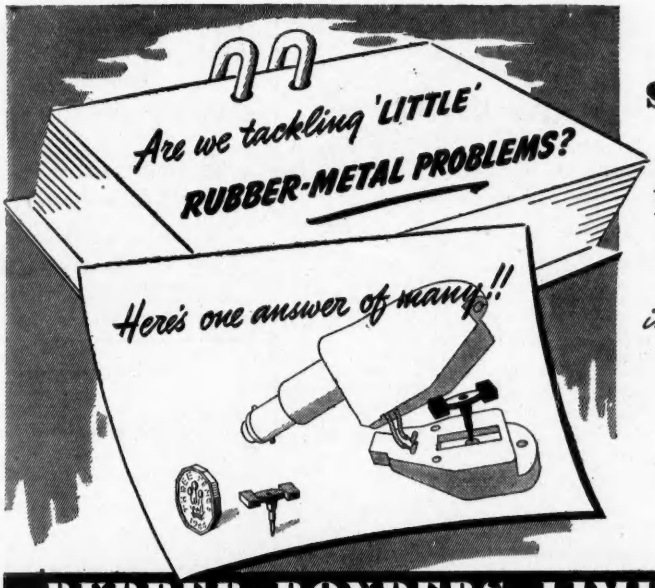

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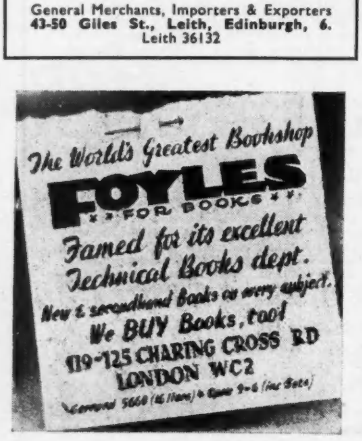

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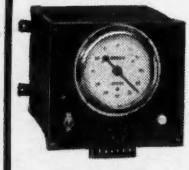

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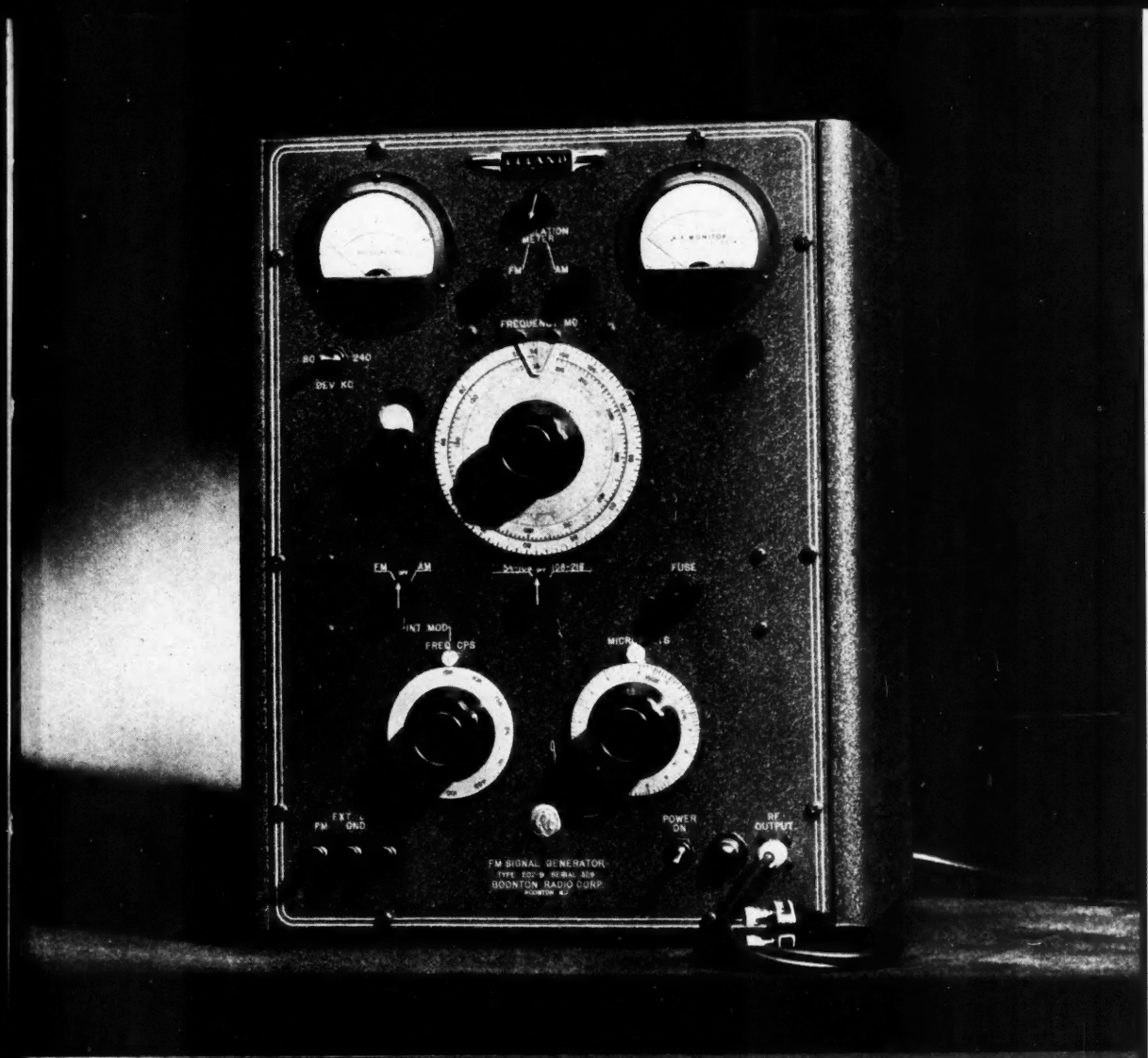

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